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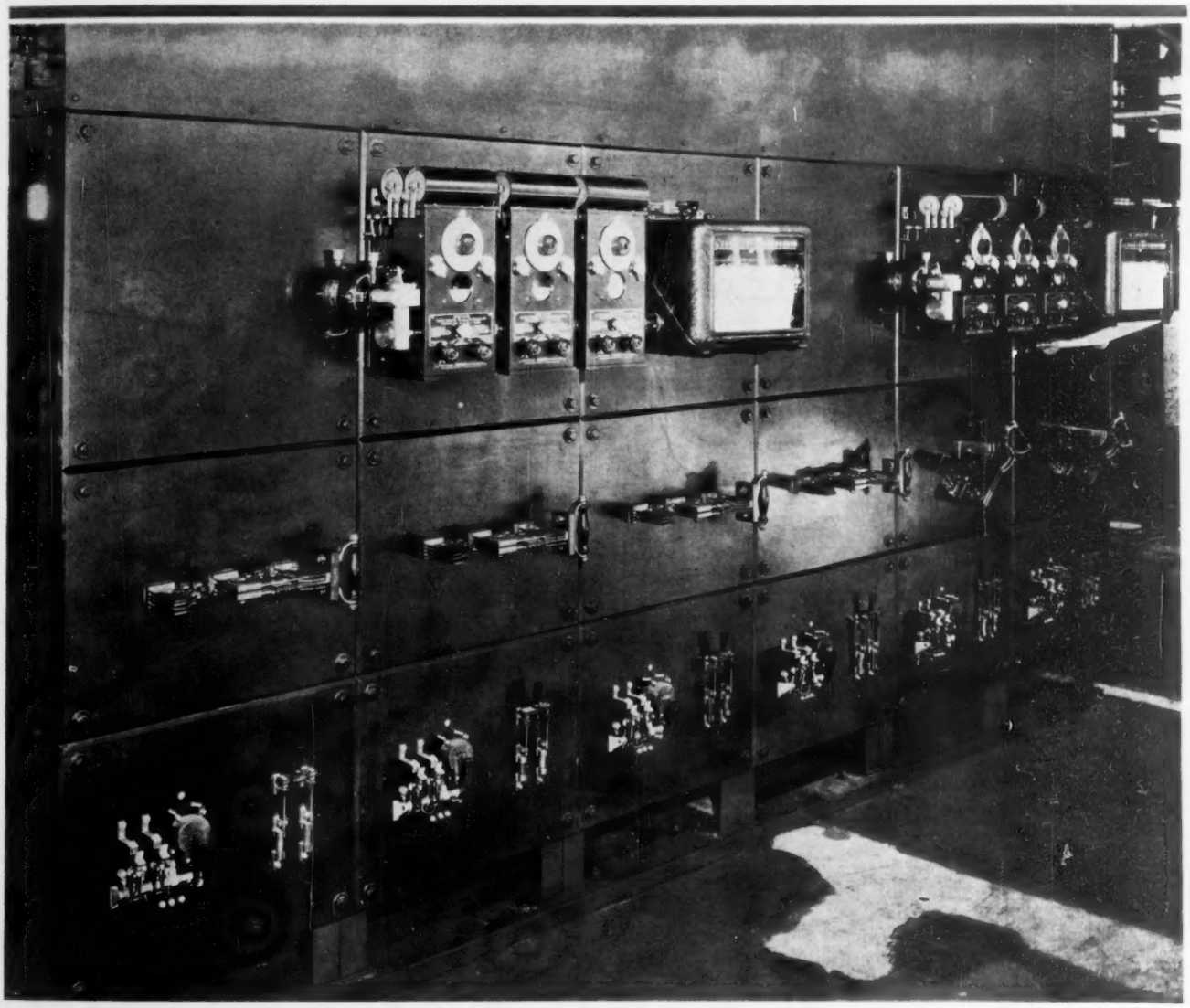
INSTRUMENTS

THE MAGAZINE OF

MEASUREMENT AND CONTROL

Volume 8 FEBRUARY 1935 Number 2



FURNACE CONTROL BOARD AT EATON MFG. CO. PLANT, DETROIT, MICH.
(Courtesy The Foxboro Co.)

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A DROP 50 FEET

left this Bakelite Molded Case

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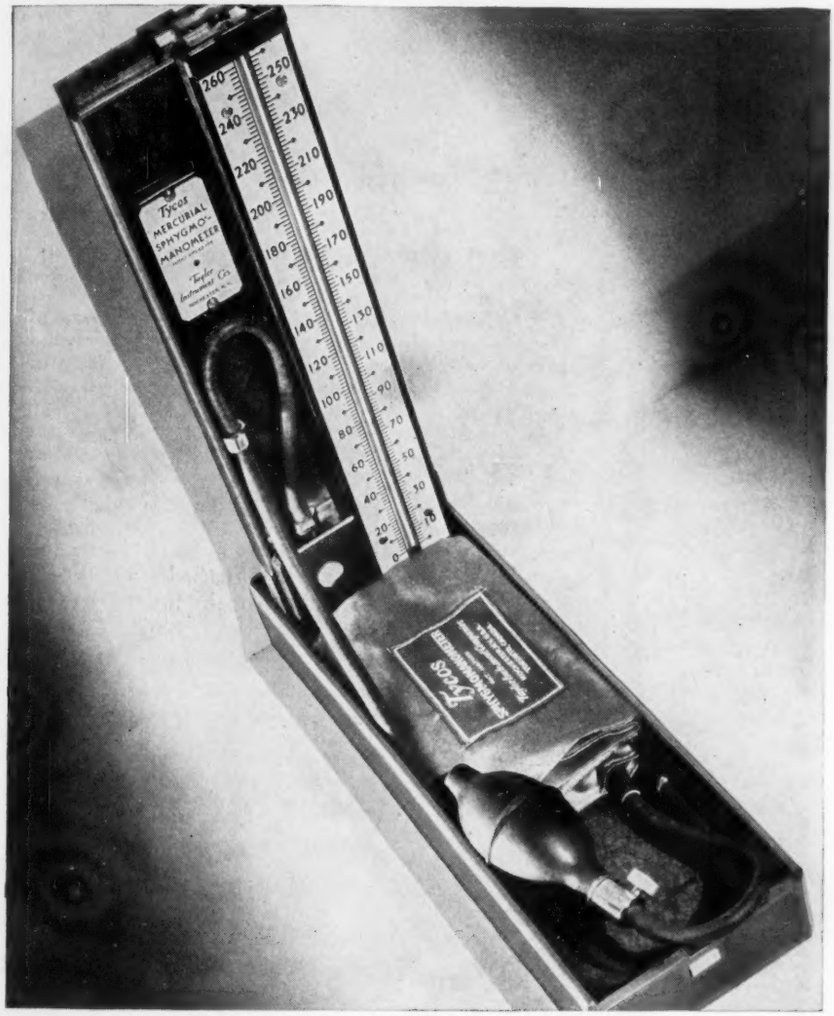
THE mercurial sphygmomanometer is a sensitive instrument for determining blood pressure, and it must be protected from mishaps by the sturdiest kind of a case. After experimenting with various materials the Taylor Instrument Companies adopted Impact Bakelite Molded for the case of the Tycos Mercurial.



Rigorous tests to which this delicate instrument is rarely subjected, demonstrated the ability of the case to stand up in ordinary service. To quote the Taylor report of these severe tests, "We have pushed the case repeatedly off the edge of the desk onto different types of floors and it has stood up remarkably well. Next we dropped several cases out of a third story window onto an asphalt pavement. Outside of minor chips these cases remained intact. Finally we took the finished instrument with the glass tube, bulb and everything in place, including the mercury in the tube and dropped it from the roof of our building to the ground below. This is a drop of some 50 feet and the case was not damaged."

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★

Photo shows Tycos Mercurial with case of impact Bakelite Molded. Product of Taylor Instrument Companies, Rochester, N. Y.

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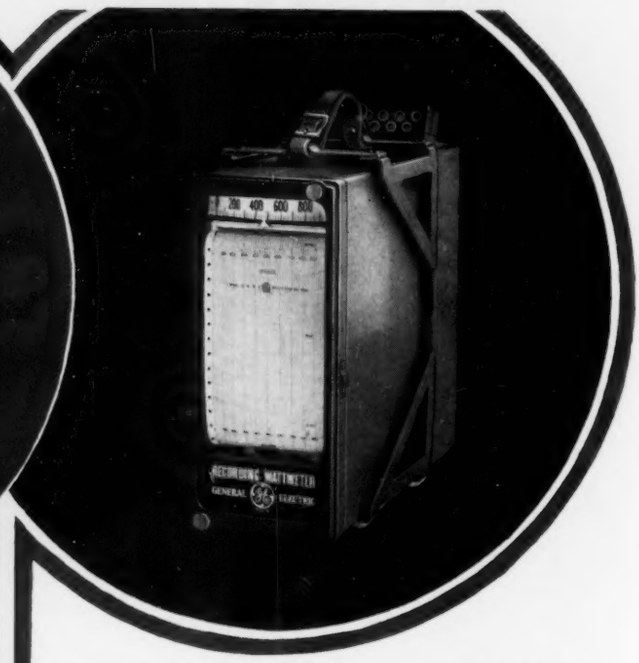

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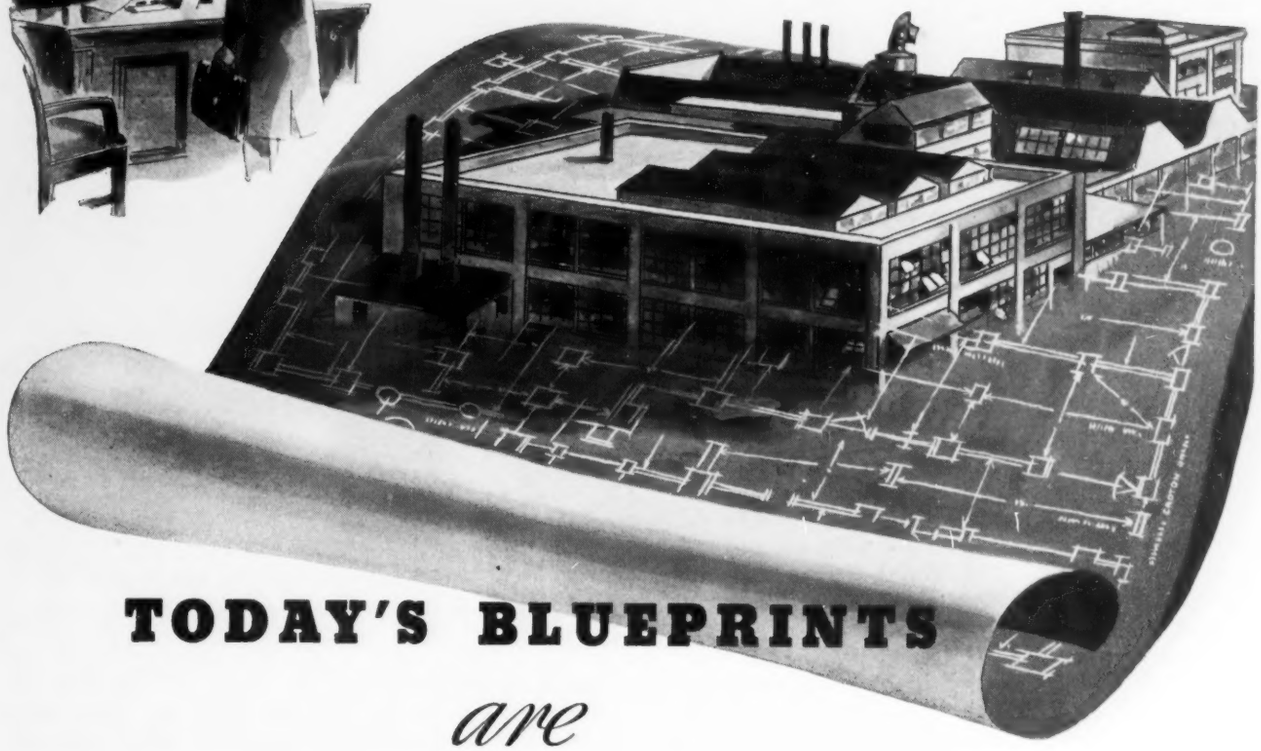

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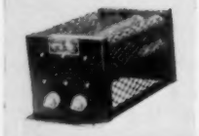

ENCLOSURES

MOUNTINGS

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Tells about Vitrohm Wire Wound Resistors, gives sizes, watt ratings.

BULLETIN 19

Describes Ward Leonard Ribflex Resistors for unusually heavy duties.

BULLETIN 25

Is a treatise of standard and special mountings and enclosures.

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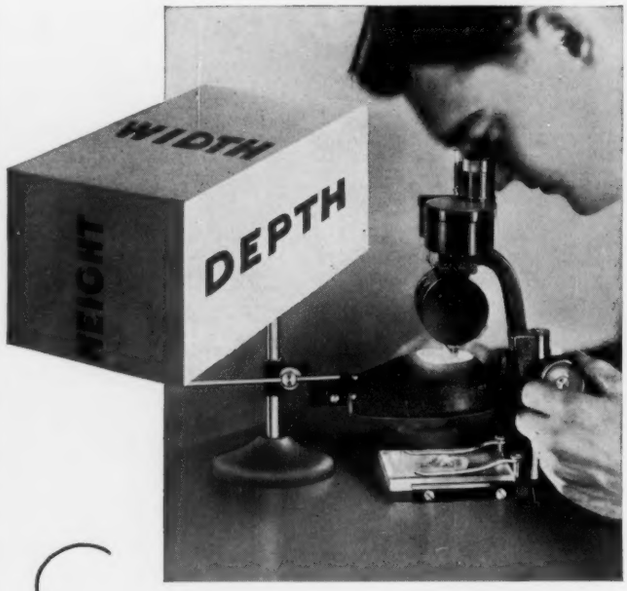

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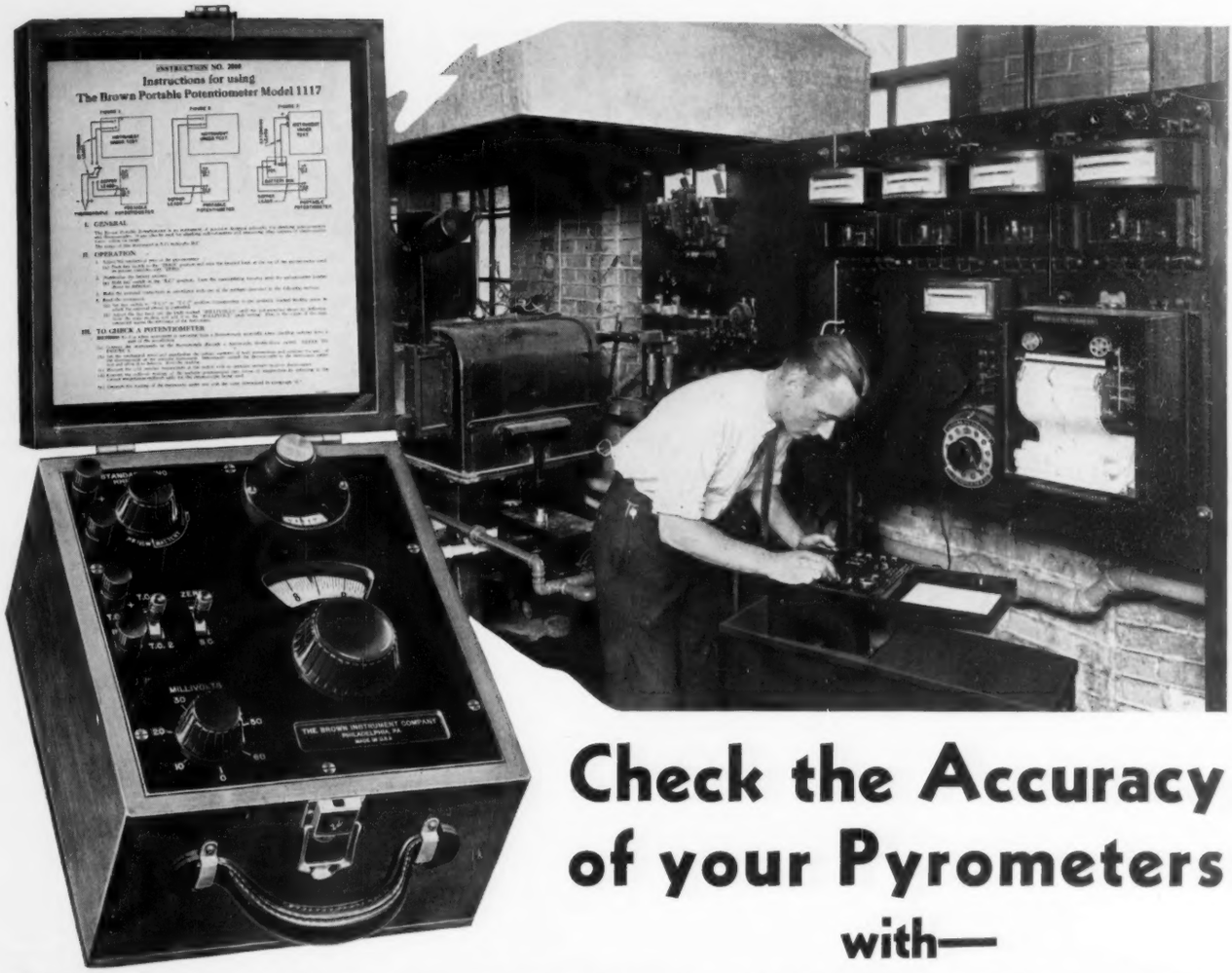

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INSTRUMENTS

THE MAGAZINE of MEASUREMENT and CONTROL

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EDITORIAL COMMENT

In This Issue

For the first time in its history—and this is the eighth year of it—*Instruments* prints a feature article on an instrument that never was built, and that never will be manufactured in the form described. At the end of this leading article we list reasons for our unusual action. In this column it may not be amiss to express the hope that our printing A. M. Dudley's report of a failure will satisfy those who accuse us of claiming that all the world's physical problems can easily be solved by instruments. Enthusiastic we are, fanatic in some respects we may be, but lacking a sense of values? Never!

Have you a little oscillograph in your lab or plant? If not, study F. D. Fielder's article on page 32 and read the column at the right . . . It won't be long before you join the ranks of fluorescent-screen observers.

Though quite smitten with oscillographitis, we remain true to our old loves, and have no hesitation in declaring that the relay type recorders dealt with in the current chapter of the electrical measurement serial are the élite of all industrial recording instruments. Professor Callendar certainly started something back in '99 at McGill University!

Then comes, on page 46, an article describing performance and endurance tests on telephone cords, written by K. W. Graybill who designed the equipment and supervised these tests. We are indebted to *The Strowger Technical Journal* (Associated Electric Laboratories, Inc.) for the privilege of printing this article.

C. H. Gibbons continues, on page 48, his fascinating history of testing machines and ends this month's installment with his hand on the door of the modern era.

Another "first-time-in-our-history" appears in this month's New Instruments Section: the first financial instrument we ever reported—a stock market barograph (though they don't call it that).

The Front Covers

All motor car manufacturers advertise riding comfort. Springs must be right. A large proportion are made by the Eaton Mfg. Co. in Detroit. The Eaton people had furnaces built by the Electric Furnace Co. And these furnaces—of course—had to be equipped with temperature recorders and automatic controllers. This month's front cover shows six controllers and two multi-point recorders supplied by The Foxboro Co. Note the group drives.

If you've ever bought cheap imported incandescent lights, you've already learned your lesson; if not, the title page of this month's Inspection and Testing Section should induce you to patronize reputable American makers such as, for example, the General Electric Lamp Co. where the photograph was taken.

Erratum. Last month's front cover photograph was not a French boiler control panel as we reported, but another by Bailey Meter Co.: the sludge control panel which they supplied to the City of Cleveland for its Easterly Sewerage Treatment Works. Our fault.

This and That

Moving. The editorial office of *Instruments* was moved on February 1st from New York to Pittsburgh. At the moment of writing, to be sure, we're not quite unpacked and we must ask the forgiveness of many friends whose letters we are slow to answer; but it is a pleasure to announce that much more floor space is now available for the executive, editorial, circulation, advertising and information departments. In fact, all of us are prepared for the expansion which we feel sure is coming within a few months.

Study the New Instruments. Voltaire—or some other thinker to whom epigrams are usually attributed—declared that the only unchangeable thing in this world is change. This is particularly true of industrial equipment. To be sure, there is little replacement of major items these days, but wide-awake production and inspection men are not crying over slim budgets: unable to scrap obsolescent boilers, furnaces, stills, evaporators, etc., they modernize them by equipping them with recorders, meters and automatic controllers.

Oscillography. Thanks to the appearance of numerous specific-purpose cathode-ray tubes and to the standardization and cost-reduction of general-purpose oscillographs and accessories, a new and useful branch of Instrumentation is rapidly being developed. The cathode-ray oscillograph—once a tool of laboratory research—now seems destined to play an important part in the solution of baffling production problems, not only in the electrical and communication fields, not only where time is a factor, but wherever two or more variables are to be studied. This means practically the entire field of non-electrical physical measurements—and a few chemical measurements as well! It no longer is a trick to convert non-electrical magnitudes into proportional voltages. Apply two of these to the deflectors of a "bottle" and you've got a high-speed engine indicator, a rapid-cycle stress-strain recorder, etc.—in short, a two-component analyzer for innumerable new applications other than those frequently reported in electrical magazines and summarized in *Instruments* in such articles as Mr. Fielder's. In order to extend the uses of the cathode-ray oscillograph, however, non-electrical engineers will have to familiarize themselves with this instrument. We intend to make it easy for them to do so: an outstanding specialist is now completing a series of articles to be published serially in *Instruments*. In conferences on this project we read portions of his manuscript and we can assure you that there's a real treat in store for you.

M. F. BEHAR

Relativity's Reality Foils Development of "True Direction" Instrument for Aircraft

By A. M. DUDLEY*

EINSTEIN'S theory of relativity is often mentioned as being too profound for ordinary comprehension or it is mentioned humorously as being so highly theoretical that no practical manifestations of it are possible. If the relativity principle really is valid, there must be physical manifestations of it around us at all times, as there are of any other principle. The difficulty lies in recognizing them.

A fairly simple example of the operation of the relativity principle recently came to light in considering an ingenious idea for an airplane compass. For aerial navigation there is need of a compass which would indicate not the direction in which the airplane is pointing (that is, the direction of its longer axis) but the direction of its motion relative to the earth's surface. Referring to Fig. 1, if an airplane is traveling in direction *OD* at velocity *OA* and there are no other forces acting, such as wind, an indication of the compass direction of *OD* would suffice to determine the flight of the airplane relative to the earth's surface. However, if a lateral wind is blowing with velocity *AB*, then the actual motion of the airplane relative to the earth's surface is along *OC* and mere knowledge of the direction of *OA* shown on the mariner's compass no longer suffices.

One way of expressing a phase of the theory of relativity would be to say that it is not possible to determine the relative position of two moving objects without making observations from one to the other or without making observations on both simultaneously from some third outside object. This is illustrated in the airplane "true direction" problem. Suppose that an airplane goes up over New York City through the ceiling, that is above the clouds. Suppose then that by his compass (mariner's or gyroscopic or earth inductor) the pilot flies due west for 3 hours, being out of sight of the earth during the entire time. He knows the approximate speed of his plane, he knows that he is keeping his head *pointed* west, but he cannot know for certain whether he is over Canada, Illinois or Tennessee, because he cannot know how far he has been blown off his course. He may make allowance for this and steer accordingly but he has no check. Hence, the need of a compass which would show the true direction *OC*—the direction of the airplane's motion relative to the earth.

*Development Supervisor, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

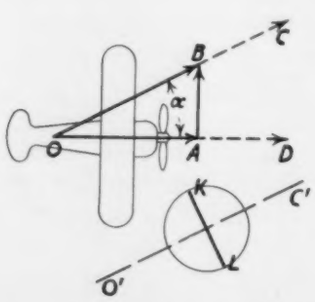

Fig. 1. Course of an airplane altered by lateral wind.

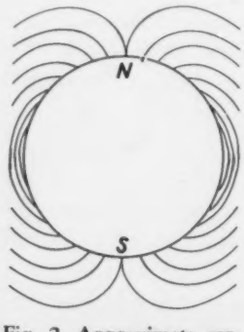

Fig. 2. Approximate representation of earth's magnetic field.

The instrument which was proposed to solve this problem accomplishes this result by utilizing the earth's natural magnetic field in a novel way. Referring to Fig. 2, the light lines represent magnetic lines of force issuing from the North magnetic pole of the earth and re-entering the earth at its South magnetic pole. From Fig. 2 it will be noted that at the magnetic equator these lines of force are parallel to the earth's surface, and that elsewhere on the earth's surface they incline, as indicated in Fig. 3. Where this condition exists the magnetic field can be considered as having two components, *OH* and *HV*, respectively parallel to and perpendicular to the earth's surface. Component *OH* always points North and South (magnetic) and is the one commonly used to determine the direction in which a boat or plane or dirigible is *pointing*, whether the craft is in motion or at rest. To determine the direction of the craft's *motion* by means of this component, an instrument must include a timing or velocity element in its fundamental design. Fig. 4 is a diagram of the ingenious instrument which was proposed. It comprises a motor with a vertical shaft upon which are mounted coil *GH* with its plane vertical, and single conductor *KL* perpendicular to the vertical shaft, hence rotating in a horizontal plane. If the arrangement shown in Fig. 4 is driven by the motor in the oblique field shown in Fig. 3, the result is that the coil *GH* shows on voltmeter *H* a voltage due to rotation in the horizontal component *OH* of this field. Similarly, when the airplane is in flight, voltmeter *V* which is connected to the two ends of single conductor *KL* shows a voltage due to cutting the vertical component of the field. No voltage is shown on *V* when the airplane is at rest relative to the earth, because one half of *KL* is cutting the field in one direction and the other half in the other, causing plus and minus voltages which cancel out. However, when the airplane in motion carries *KL* through the vertical component, a voltage is generated in *KL* due to this motion of translation relative to the earth.

The small voltages thus generated are alternating. When the plane is in flight there are two sine curves of voltage, one made by the coil operating in the horizontal

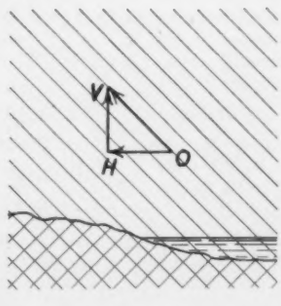

Fig. 3. Horizontal and vertical components of earth's magnetic field.

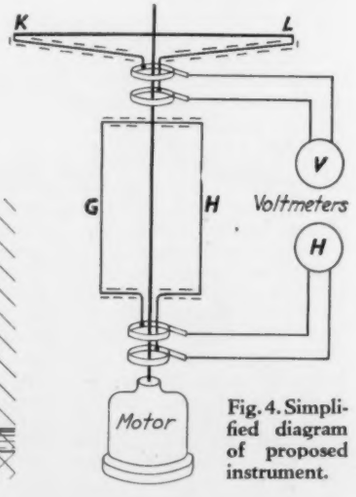

Fig. 4. Simplified diagram of proposed instrument.

magnetic field and shown by voltmeter H, and one made by single conductor KL operating in the vertical magnetic field and shown by the voltmeter V. These two curves, as shown in Fig. 5, are almost never in phase, the reason being as follows: Coil GH, rotating in the horizontal field, develops its maximum voltage at the instant when its flat dimension is directly North and South, because at that instant its wires cut the magnetic field at the fastest rate, since the horizontal component always

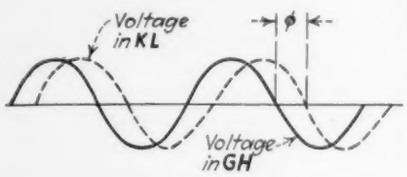

Fig. 5. Graph showing phase angle between voltages in KL and GH corresponding to angle between airplane's direction of axis and direction of flight.

points North and South. However, the voltage caused by KL being carried through the vertical components of the terrestrial lines of force is at its greatest when KL is directly perpendicular to the direction of the airplane's *actual* horizontal motion, as shown in Fig. 1 where KL is perpendicular to OC.

As the readers of *Instruments* know, there are various methods of determining phase angle, and instead of voltmeters H and V it is a simple matter to connect an instrument which will indicate ϕ (Fig. 5). The beauty of this solution is that the electrical degrees in ϕ are exactly the same as the mechanical degrees in α (Fig. 1) and hence show at once how the airplane is actually moving with reference to the way it is pointing.

Apparently, then, what seemed impossible has been accomplished and a lone observer flying for hours above an ocean of water or of clouds is able to tell exactly in what direction he is traveling, by simply using the new instrument to correct the indication of his ordinary compass. Then, by reference to his air-speed indicator, to the latitude and longitude of his take-off (or last visible point) and to the elapsed time, he can always know where he is! *But it will not work.* And the reason it will not work is that same relativity principle of Einstein's with which this article was opened. The mathematical explanation of why it will not work may be omitted here. The reason can best be stated by quoting Dr. Slepian, to whom the supposed "solution" was submitted.

Dr. Slepian stated that "the readings of the instruments on the airplane will be the same as if it were at rest in some horizontal electrostatic field observed by some stationary observer on the earth. Hence unless an observation of the electrostatic field is made at the earth, no conclusion can be drawn as to the motion of the airplane relative to the earth. Since the electrostatic field at the earth is quite variable, the proposed method of determining the airplane motion is impractical. The principle of relativity affirms that the motion of the airplane cannot be determined by observations with instruments on the airplane alone. The readings of instruments on the airplane can be ascribed to an electric field and motion in a magnetic field, but how much of the reading is to be attributed to the electric field, and how much to the motion in the magnetic field is entirely indeterminate, and can only be settled by an observation of the electric field by an observer at rest with respect to the earth."

This is another way of stating that it is impossible to measure the relative motion of two bodies without taking physical observations from one to the other or by making observations on both from a third point outside of both. In the method described it would seem that the earth's magnetic field constituted a medium for relating the airplane to the earth, but the expression of that field, while handy for ordinary calculations, is a purely artificial convention and does not get over the fundamental difficulty.

Thus a beautifully ingenious solution for a real problem apparently came to naught, but the incident reported is most useful in demonstrating that Einstein's theories are much more than an academic dream and that relativity really works.

There are several reasons why we have accepted the above article.

First, 1934 is the Centennial Year of the science of terrestrial magnetism: one hundred years ago Gauss founded it by initiating regular observatory measurements at Goettingen. Since then, numerous magnetic observatories have been established all over the world, where precise measurements of the elements D, I, H, V and R are made 24 hours a day. Societies have been founded in almost every civilized country. Periodicals are published in various languages. The century of progress in this science closes with a world-wide organization.

(Every accretion of knowledge, however, has but deepened the mysteries of terrestrial magnetism. No one has the least inkling of its origin. Nobody can explain its variations, the cycles of which range from hours to centuries.)

The second reason why we print the article is that we do not accept as final our esteemed friend Dr. Slepian's pronouncement that a true-direction instrument of the *general* type proposed is an impossibility. Therefore we not only publish the report that "Relativity" foiled one attempt to design a true-direction compass, but we cheerfully give publicity to the attempt itself.

Thirdly, granting that an instrument of the *particular* type described will not work, and in spite of our respect for the scientific achievements of Dr. Slepian, we do not accept as final the explanation that it is Einstein's principle that would prevent this type of instrument from working. From Maxwell's field equations it has long been known that to a fast-moving observer a static charge is a current. Maxwell's equations indeed, by a simple change of notation as suggested by Professor Wilson of London University, can be made to take the form now used for expressing tensors in a 4-dimensional continuum. True, it was Einstein who conceived and formulated the principles of Relativity which banished time and space as separate entities in physics and definitely postulated the 4-dimensional continuum, but we believe that if the above article were brought to his attention, he would say "Nobody needs my equations to understand that to the pilot of a fast airplane the earth's electrostatic field appears in part as an electromagnetic phenomenon."

Finally—and most importantly—the very fact that no one has yet built a successful drift indicator or true-direction compass emphasizes the need of open discussion. *Instruments* stands for progress in aircraft instruments and will gladly publish interesting discussions of the idea reported by Mr. Dudley or of other true-direction schemes. We particularly desire reports of investigations actually conducted, with analyses of results obtained, which have not yet been published elsewhere. Send them in!

M. F. BEHAR

Some Applications of the Cathode-ray Oscillograph

Examples Selected from High-tension Line Work, Radio-frequency Insulation Tests, etc.

By F. D. FIELDER*

FOR the study of high-speed transients the cathode-ray oscillograph was first used as a recording instrument by Dufour in 1918. However, extensive practical application of this type of oscillograph did not occur until about eight years ago, when it was used for surge measurements. Although its principal use is still the measurement of surge voltages, other related problems have been solved just as effectively. This discussion presents some typical examples of the application of the cathode-ray oscillograph.

The reason that the cathode-ray oscillograph is so valuable is the unique feature of distortionless recording. The negligible inertia of the electron beam eliminates the damping effect which is present in every other kind of oscillograph. In many kinds of measurements this feature completely overshadows the disadvantages of higher cost, of extensive auxiliary apparatus, and of high caliber operating technique.

Routine surge investigations comprise the most extensive application of the cathode-ray oscillograph. In these tests the oscillograph adequately records voltage measurements, time intervals, and complete wave shapes. Fig. 1 illustrates this most common use, a flashover of ordinary high voltage apparatus—in this example a string of suspension insulators. This oscillogram shows clearly a surge voltage of 675,000 volts causing a flashover with a time lag of 12 microseconds. In four Westinghouse laboratories, records of this nature are made in an amount totaling 1000 or more per month.

A record of similar nature, but involving no breakdown, is a voltage distribution wave, as shown in Fig. 2. This record is typical of studies of surge distribution in transformer and generator windings, which are made by impressing surges on the terminals of the windings and measuring with the oscillograph the resulting voltage waves at different points within the windings. These studies are valuable in determining the portion of the winding subject to the greatest stress, with consequent improvement either by electrically reducing the stress or by increasing the insulation at the weak points.

A third application of similar nature is the testing of lightning arresters. In these tests specifications call for definite currents and definite wave shapes, so that a cathode-ray oscillograph is necessary. Currents are measured by recording the voltage drop across a non-inductive series resistance placed in the ground side of the arrester. Since in most laboratories surges can be repeated accurately, oscillograms showing both voltage and the corresponding current can be obtained with two consecutive surges.

A second class of application is the use of the cathode-ray oscillograph in measuring surges superimposed on 60-cycle frequencies. In these cases it is customary to record either several complete cycles, or at least a good portion of one cycle. Typical of the first case is the recovery voltage after a circuit breaker operation, as shown in Fig. 3. This oscillogram was obtained with a film revolving on a drum as with the magnetic-type oscillograph. The voltage surges appearing on this film would be almost entirely missed with the ordinary oscillograph.

A parallel case, but in a different application, was the result of a study of the disturbances arising from intermittent brush-corona discharges which sometimes occur with 60-cycle voltages above the disruptive potential. Fig. 4 shows an oscillogram of such a discharge taken in the normal manner with a stationary film. In

*M. & P. Engineering, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

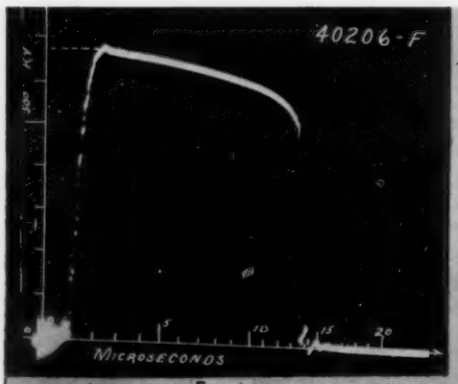

Fig. 1.

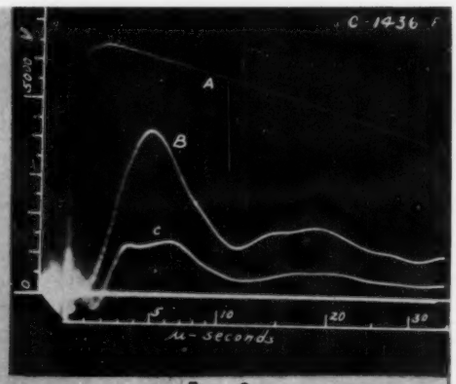

Fig. 2.

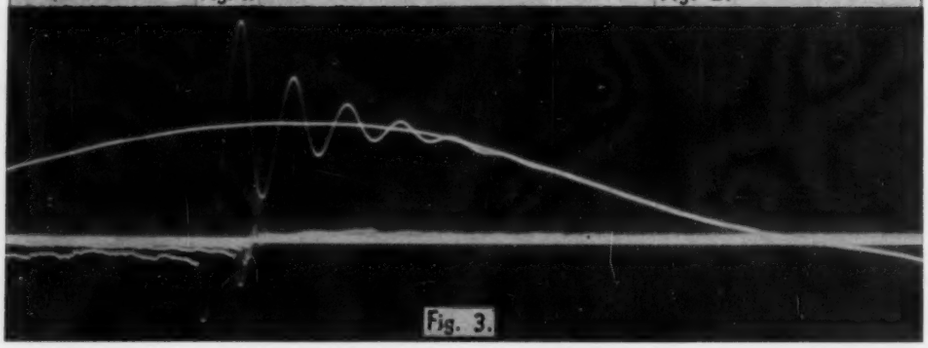

Fig. 3.

Fig. 1. Flashover of a string of seven suspension insulators.
Fig. 2. Distribution in a generator winding: A—Applied wave; B, C—Resulting internal waves.
Fig. 3. The recovery voltage after a breaker operation. Film revolved six times.

these tests several trials were required before a successful film showing the desired disturbance was obtained, because of the irregularity of the phenomenon.

Cases between these extremes are sometimes encountered. For example, in certain coil tests a high frequency voltage is used to show up faulty insulation. Although calculations were made of the wave form, and wavemeter measurements showed the resonant frequencies, it was more conclusive to have actual oscillograph measurements to show all of the details of the wave trains. Figs. 5 and 6 are two interesting oscillograms resulting from this work. Included is a timing oscillogram, Fig. 7, showing the simple measurement of a typical high frequency wave. This represents one of the simplest of all cathode-ray oscillograph applications.

Thus in the few years of active cathode-ray oscillography many uses have arisen requiring the unique feature of distortionless recording. Modern cathode-ray oscillographs, with complete and compact auxiliary apparatus, have successfully fulfilled all expectations in the problems arising to date. And since practical use of the oscillograph is so recent, it is to be expected that its applications will increase extensively. The applications described in this article are but a few among many and varied examples.

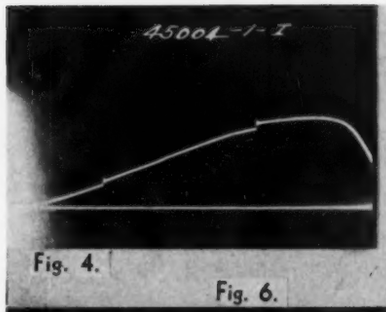

Fig. 4.

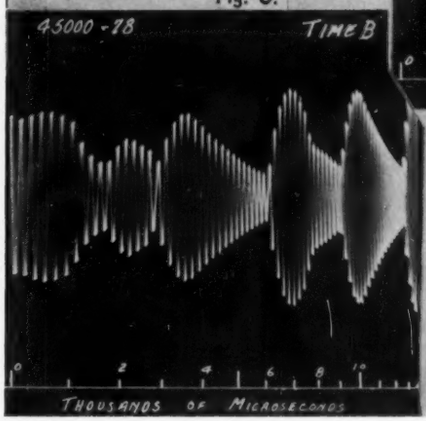

Fig. 6.

Fig. 4. Static brush corona modifies smooth waves.

Fig. 6. Wavemeter coil oscillations.

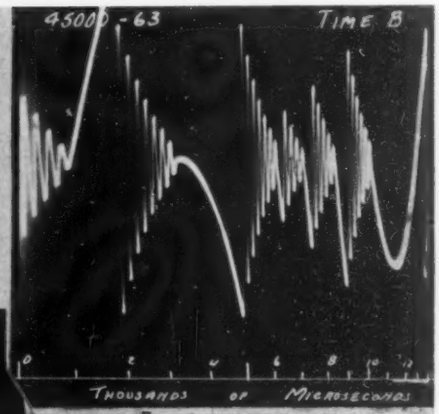

Fig. 5.

Fig. 5. High frequency for coil tests.

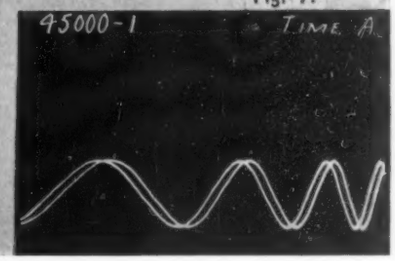

Fig. 7.

Fig. 7. Simple timing wave.

INSTRUMENTS' BOOK SHELF

Television, Theory and Practice. By J. H. Reyner. Chapman & Hall, London, 1934. Cloth, 5¾x8¾ inches. 196 pages. Price 12s/6d.

In the international race for the honors of first putting television into the ether on the grand scale, it is interesting to note that most of the books on the subject originate abroad. In this most recent treatise of television one will find a good review of the art in not too technical language. It is still the fact that the system which has the greatest chance of becoming widely used, cathode-ray scanning, has the least space devoted to it, probably because so little is known about this phase of the art outside the laboratories where it is being developed.

The chapter headings give a good idea of the contents, such matters as optical systems, the place of the eye in television, the characteristics of photocells, the cathode-ray tube, film television, contrast of the American and the European plans, color television, and the like being handled in good fashion. There is little mathematics in the book, and not many illustrations (88) considering the scope of the subject. But it is a good review of the past art and as much of the present as is attainable, probably.

Various scanning systems are taken up in sufficient detail. Thus the disk methods, those using rotating mirrors, and oscillating devices are described. Methods of attaining time bases for cathode ray apparatus are given a full chapter, but in eleven pages of rather large type it is impossible to do more than skim the surface of this subject. This is not to be taken as the fault of the author; an entire volume could be written about this single portion of the television problem, so vast has become the printed matter on this subject.

The names already well known in the television art are given due credit. Thus Nipkow, Alexanderson, Mihaly, Zworykin, Farnsworth, Baird, and Von Ardenne are mentioned many times. Among the special systems—and the patent literature is becoming replete with new methods of transmitting moving scenes to a distant looker-in—may be mentioned the variable-speed scanning, in which the spot moves slowly over the bright portions of the scene and rapidly over the dark portions; the Scophony system of Walton in which the picture is split up into a single continuous line, thus doing away with one scanning direction; and the zone television of Gramaphone in which the television signals were split into several sections, each section to be transmitted over a distinct wire or radio channel.

Some errors attributable to hasty preparation lessen the value of the book as a technical reference. Thus the text mentions Fig. 22 as giving response curves of photocells and of the human eye, but the eye sensitivity curve was not drawn in. Two pages further, the textual reference to Fig. 24 contradicts the caption below that diagram.

It is worth noting that the author speculates on the reason why so little progress of the art has come from America in comparison with that originating abroad; he notes that broadcasting had its greatest technical growth here and that American engineers seem to get ahead no faster than those in Germany or England. Perhaps it is that so few large organizations have tackled the problem in America and those who have accomplished results have been so careful to impart as little information as possible. One wonders what the state of the art would be if there were free interchange of technical information.

Keith Henney (5.3)-B-

Electron Tubes in Industry. By Keith Henney. McGraw-Hill Book Co., New New York, 1934. Cloth, 6 x 9¼ inches, 490 pages. Price $5.00.

It is not surprising that so many industrial inspection, measurement, and control devices make application of principles and equipment developed for radio and communication purposes. Devices tending to make many production processes automatic and utilizing for the most part electronic tubes, are finding new uses daily. Publicity has not been lacking in the popular press for many of these contrivances, but it has been difficult for an industrial engineer or production manager to determine the essential details from such accounts or even to judge if they merit personal consideration for his own problems.

The author of this interesting book has assembled descriptive details of some of these applications that have proved of value in industry. The presentation in all cases is from the practical viewpoint, with a minimum of the theoretical and mathematical aspects, but with sufficient data on the circuit and apparatus arrangements to enable

(Continued on page 50)

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Recording Electrical Instruments

II—Relay Types*

By PERRY A. BORDEN† and M. F. BEHAR**

2. Electrical-relay Types

(Continued)

(h) Bailey

Brought out in 1934 for temperature measurements with thermocouples or with resistance thermoelements, the Bailey Meter Co.'s "Galvatron" is an industrial round-chart recorder housed in the same rectangular case as the makers employ for their flowmeters (see Part Six), likewise capable of being made up in multi-pen models, and with all working parts assembled on a hinged aluminum panel. Fig. 41-16 shows a view of the back of the panel of a four-pen "Galvatron." The name is derived from the employment of electron tubes to amplify the few microamperes of current carried by the galvanometer contacts.

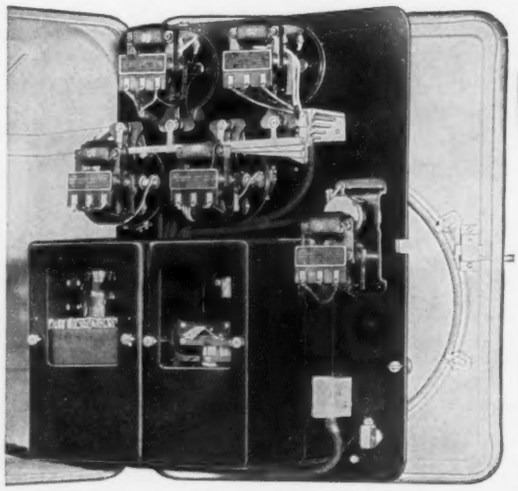

Fig. 41-16

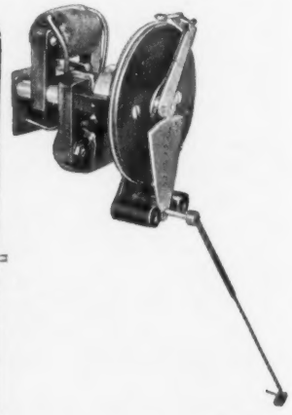

Fig. 41-17

Since contacts are opened and closed at the galvanometer, the instrument is distinctly of the electric-relay type, not of the electronic-relay type to be discussed in Section 4. Fig. 41-17 shows the mechanical element of the Galvatron. A reversible Telechron motor adjusts a sliding contact along a circular slide wire and at the same time positions the recording pen through a gear sector distinctly seen in the illustration. Each winding of the motor is connected to the a.-c. supply through one circuit of a reactor having two windings, and under normal conditions the inductance of each reactor limits the current flow to a value which will not rotate the motor. A short-period galvanometer in the balancing circuit is arranged to make contacts of a duration proportional to the galvanometer deflection from its neutral position and either contact, acting through an electronic tube, serves to pass a direct current through a winding on the corresponding reactor. The direct current saturates the iron core of the reactor, thus reducing its inductance to a point where there is permitted an alternating current flow sufficient to operate the Telechron motor in a sense to restore the balance of the circuit.

*Thirteenth chapter (XLI) of Part Seven (Handbook of Industrial Electrical Measurements and Control) of Béhar's *Manual of Instrumentation*. See editorial announcement of this series on page A7 of November 1933 *Instruments*. A complete chapter of this new handbook is published in each issue of *Instruments* throughout 1934 and 1935. Each chapter is subjected to a final revision, and then set in type, shortly before its appearance in this serial form, in order to assure that the subject matter is thoroughly up-to-date. This new book is not published serially in any other periodical. Entire contents copyright. To be issued in book form on or about Jan. 1, 1936.

†Member A.I.E.E. **Editor, *Instruments*

3. Mechanical-relay Types

(a) Leeds & Northrup—Original Form and "Micromax"

The earliest (1909) and best known of the practical mechanical-relay type electrical recorders is that manufactured by the Leeds & Northrup Company. The essential operating mechanism is shown in Fig. 41-20. The galvanometer pointer, flexible in a vertical sense, swings horizontally in a slot formed by rocker-arm 5 and horizontal extension of two levers 4L and 4R pivoted at points 24E. A constantly rotating shaft 6 carries four cams, one of which, 6B, lifts arm 5 a short distance against the galvanometer pointer once in each revolution of the shaft. If the pointer is in its mid-position it passes between the extensions of levers 4L and 4R and no balancing action ensues; but if it is deflected in one direction or the other the corresponding lever is engaged and, as the pointer is lifted by arm 5, the lever is swung about its pivot point through an angle depending upon the amount of pointer deflection. Friction wheel 1 is connected to the sliding contact of the balancing circuit and to the recording pen carriage, so that if this wheel is rotated the slider and the pen will be correspondingly shifted. Rocker arm 3 carries a cross beam 2, pivoted concentrically with wheel 1, and bearing friction pads which engage the rim of the wheel as arm 3 is urged toward the wheel by a spring. Cam 6C on shaft 6 periodically moves arm 3 and beam 2 away from the wheel so that as rocker arm 5 rises, beam 2 is free to swing about its center of rotation. Pins 2C on beam 2 are engaged by levers 4L and 4R; and as one or other of these levers is deflected through a small angle by engagement with the galvanometer pointer, the beam is rotated through a proportional but much larger angle.

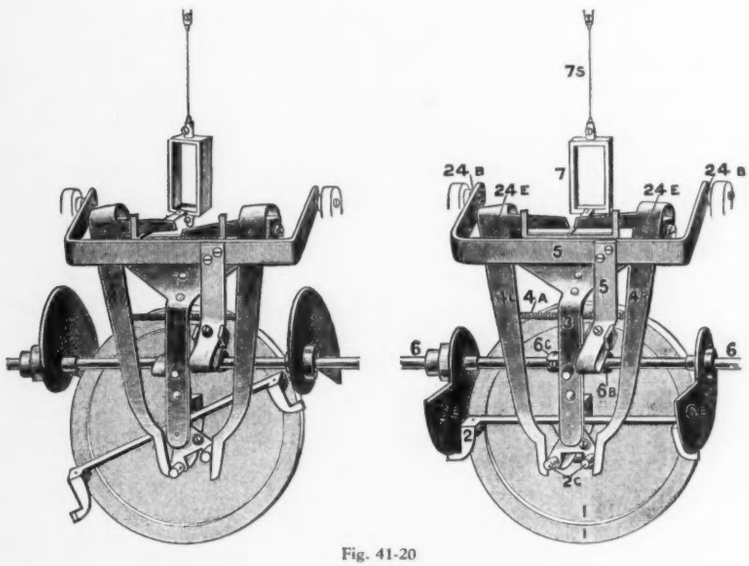

Fig. 41-20

The deflected beam is then allowed to engage the rim of friction wheel 12; and immediately one or other of two identical wiping cams 6E engages an extended end of the beam 2, rotating it to its neutral position and at the same time carrying the wheel through a corresponding angle, and adjusting the circular slide wire (behind the wheel) in a sense to restore circuit balance. The slide wire is a helically coiled resistance wire wrapped once about a rotatable drum. This essential mechanism is a self-balancing bridge or potentiometer but it has been applied to a variety of other uses where the null method of measurement is advantageous. The instrument has long been available as a multiple-point recorder and as an automatic controller.

In the improved "Micromax" mechanism of Leeds & Northrup (1931) a somewhat different mechanical principle is utilized; but it is so designed that instruments of the earlier type may readily be equipped with the newer action. In this device, as in the original form, there is found the friction wheel and the concentrically swinging beam periodically moved into and out of contact with the wheel. Pointer *A* (see Figs. 41-21, 22, 23) is clamped once in each revolution of the cam shaft, whereupon two exploring members or "feelers," *B* and *C*, operating with a scissor-like motion, approach it from opposite sides. If the clamped pointer is in its neutral position the feelers meet at this point (see

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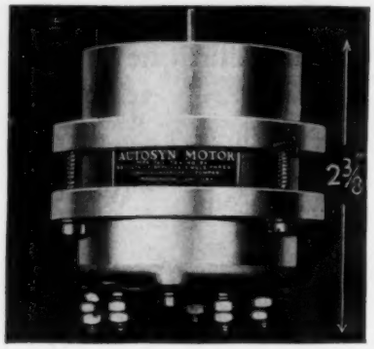

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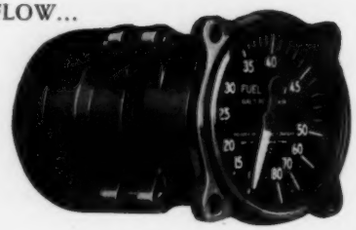

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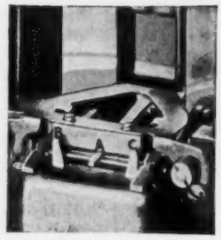

Fig. 41-21

Fig. 41-22

Fig. 41-23

Fig. 41-22) and no balancing action ensues. If the pointer, when clamped, is on either side of neutral (Fig. 41-23) one of the feelers will be stopped by it, and the other will move past its middle position till it finds the pointer. During the movement from the feeler's normal position of rest at the middle point to the position in which it engages the clamped pointer the lower end of the feeler acts against the beam, shifting it through an angle which corresponds to the excess movement of the feeler. The beam is then frictionally engaged with the wheel and, as in the earlier model, returned to its middle position by action of a spiral cam, thus giving a balancing increment proportional to the pointer deflection. The "Micromax" principle, coupled with modified design of the mechanical elements, makes possible a higher degree of precision and a greater rapidity of action than was possible with the older type.

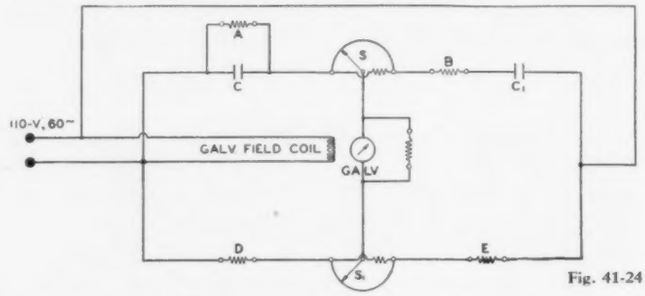

Fig. 41-24

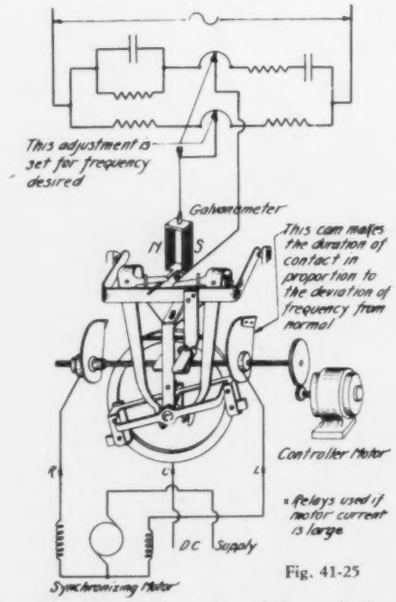

Fig. 41-25

As an outstanding example of the adaptability of the self-balancing instrument may be mentioned the L & N recording frequency meter and frequency controller. The circuit of this instrument, shown in Fig. 41-24, is that of an impedance bridge, two of the arms consisting of non-inductive resistors, together with capacitor units. In one of these arms the resistor and capacitor are in parallel and in the other in series. The balance point of such a network is extremely sensitive to changes in frequency, and an a.-c. galvanometer in the bridge circuit, acting through a "Micromax" mechanism, tends to correct unbalance conditions introduced by variation in frequency of the applied voltage. A diagram of this instrument arranged for frequency measurement and control is shown in Fig. 41-25. The standard range of the instrument for a normal 60 cycle system is 58 to 62 cycles.

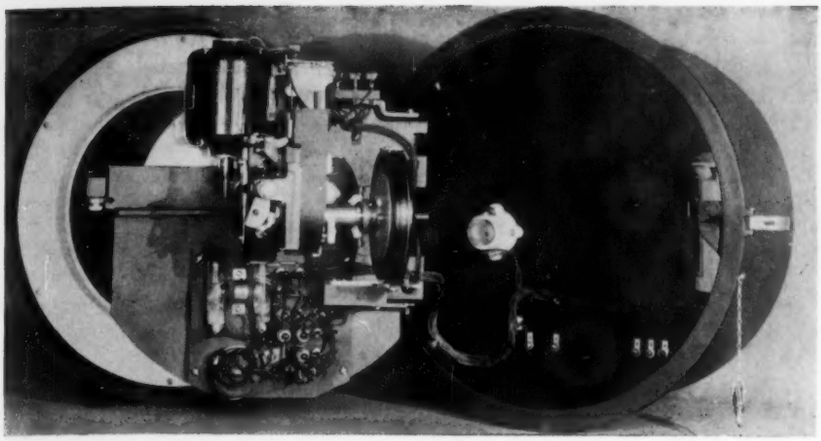

Fig. 41-26

The "Micromax" mechanism is available in a "junior" form in the L & N round-chart recorder, Fig. 41-26, having a 10⅜" chart with a scale length of 3½". The instrument is fitted also with a conspicuous indicating pointer, making its readings visible from a considerable distance. While this instrument is not capable of all that can be done with the strip-chart recorders it is particularly adapted to pyrometric work in the ordinary industrial ranges.

(b) Wilson-Maeulen* and Foxboro*

The original form Wilson-Maeulen self-balancing recorder was brought out in 1930 as a potentiometer for industrial pyrometry. It also belongs to that class wherein the galvanometer pointer is first clamped and subsequently engaged by one or other of a pair of feelers. The feelers operate concentrically with a clutch wheel in such a manner that as either of them touches the pointer its travel is stopped and the clutch is immediately engaged by a roller ratchet which carries the wheel and associated balancing mechanism through a distance proportional to that by which the pointer was deflected at the moment of clamping. A straight slide wire element is located near to, and transverse of, the chart, so that the pen carriage and sliding contact are integral parts of the assembly, making backlash between them impossible.

Fig. 41-27 is a top view of this instrument with the upper part of its case removed. Galvanometer pointer 7, flexible in a vertical sense, swings horizontally in a slot formed by clamp bar 2 and a stationary block, each of which

*In 1932 the electrical recording and controlling instrument departments of the Wilson-Maeulen Co. became the Wilson Maeulen Pyrometer Division of the Foxboro Co.

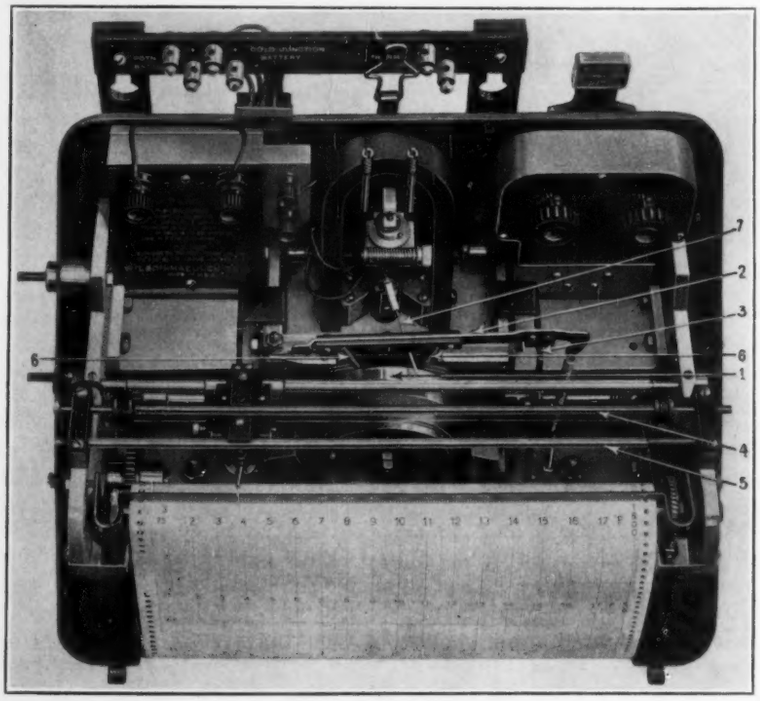

Fig. 41-27

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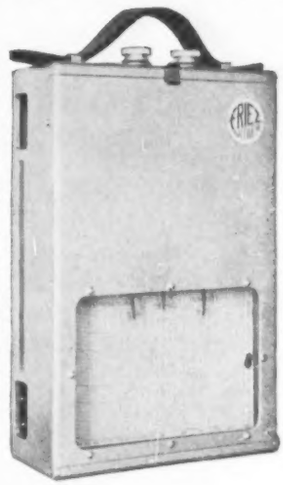

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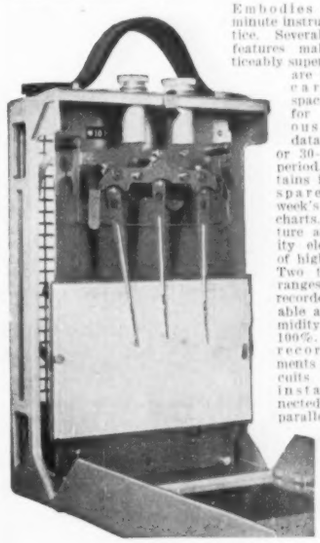

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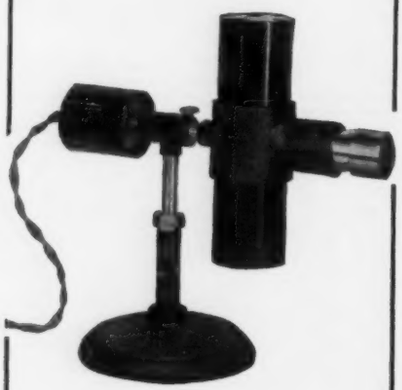

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has two parallel clamping surfaces. Clamp bar 2 is alternately raised and lowered by cam-operated lifter arm 3 and by the helical spring visible at its right end. When lowered, it locks pointer 7 firmly in place, whereupon two exploring members, 6, 6 (called "sensing fingers"), protruding from ratchet drum 1 and operating with a scissor-like motion, approach the clamped pointer from opposite sides. If the pointer is in its neutral position, sensing fingers 6 and 6 meet at this point and no balancing action ensues. If the pointer, when clamped, is on either side of neutral, one of the sensing fingers will be stopped by it and the other will continue to mid-position. Each sensing finger forms the upper end of a "release arm," the lower end of which is pivoted co-axially with drum 1 and the function of which is to actuate one of a pair of ratchet arms within the drum. These ratchet arms oscillate in opposite directions. Neither of them engages the inner surface of the drum rim until released by its release arm. If the pointer is on the right-hand side of neutral, as in the photograph, the right-hand release arm is stopped by it and drum 1 immediately starts to rotate counter-clockwise through an angle corresponding to that between the point where the right-hand sensing finger was stopped and the mid-point where it would later have stopped if pointer 7 had been undeflected. A catgut belt (which shows as a white line parallel to and below slide wire 4) converts all rotary motions of drum 1 into transverse motion of the pen-carriage and slide-wire-contact assembly. Contact rod 5 serves also as a guide for steadying the carriage.

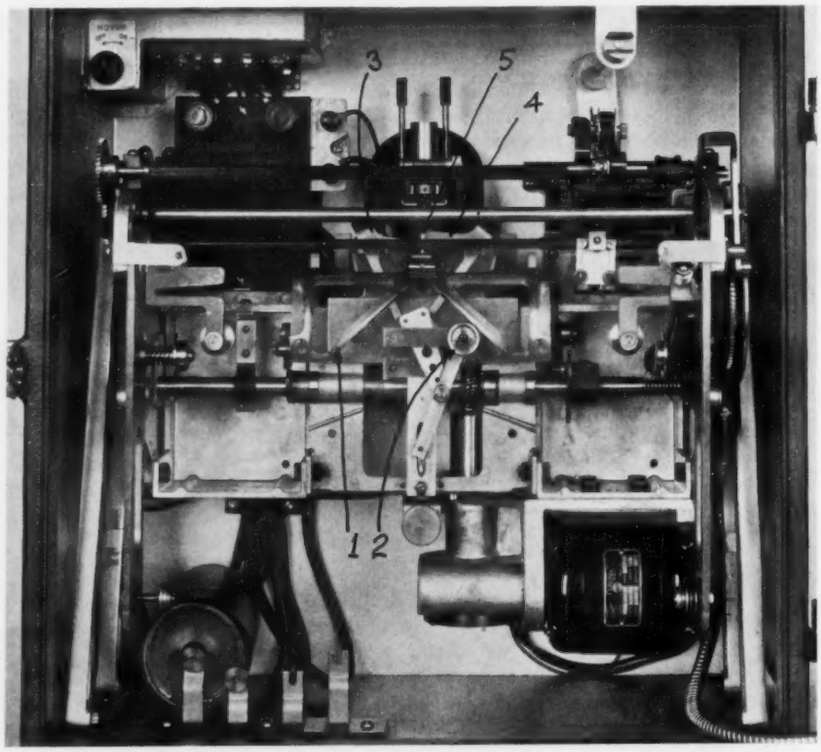

Fig. 41-28

A modified form of this recorder was brought out by the Foxboro Co. in 1933. While similar in its general layout to the original instrument, it embodies features which distinguish it from that described above. The balancing mechanism (see Fig. 41-28) comprises a cylindrical cam 1, shaped like an inverted V, and friction roller 2. "Sensing fingers" 3 and 4 position the friction roller according to the position of galvanometer pointer 5. If the pointer, when clamped, is on either side of neutral, the descent of the cam engages friction roller 2 and rolls it from the point of engagement on the cam to the center of the cam—to its original center position. A sliding pivot system, with moving fulcrum, causes friction roller 2 to move always in a rectilinear horizontal path. An endless belt (invisible in our illustration) attached to the pen carriage and encircling friction roller 2, is positioned by the friction roller whenever the cam engages and moves and rotates the roller. When the friction roller is not engaged by the cam, it is free to be rolled along the belt to any new position by fingers 3 and 4 without moving the belt or the pen. The slide wire of the potentiometer measuring system is mounted parallel with the travel of the pen

carriage and the slide wire contact is integral with the pen carriage, eliminating blacklash errors.

In single-point instruments a syphon pen is mounted on the pen carriage. Multiple-record instruments (available up to 8-record capacity) are supplied to print either dot records with individual color identification for each point, or numbered dot records with numeral and color identification for each record. The servomotor is a synchronous motor, mounted on rubber bushings to minimize vibration. The potentiometer battery is a Le Carbone cell with a temperature-responsive compensating coil.

(c) Brown

The recording potentiometer or bridge brought out in 1931 by the Brown Instrument Co. incorporates a number of interesting mechanical features which will best be understood by reference to Figs. 41-29 and -30. A galvanometer *A* is connected in a balancing circuit, and its pointer *B* periodically clamped, whereupon a selector table C is gently brought into contact with the pointer, and the position in which its stepped contour is engaged serves to locate a secondary pointer *D*. A cam-actuated step-lever *E* then moves into contact with the secondary pointer. If pointers *B* and *D* are in neutral position, no balancing action ensues. If they are on either side of neutral, lever *E*, through

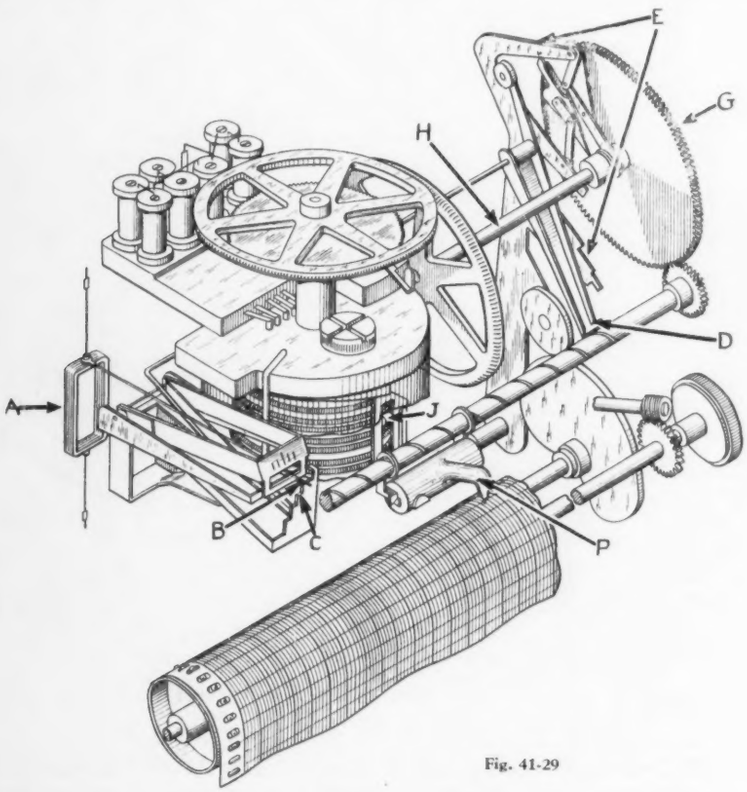

Fig. 41-29

a definite pawl-and-ratchet mechanism, rotates gear *G* on shaft *H*, through an angle and in a direction depending upon the position in which the secondary pointer *D* was positioned by the galvanometer pointer. The balancing circuit includes a helically wound slide wire having an equivalent length of 40 inches. This is enclosed in a glass container so that it may be immersed in oil which protects it from corrosive effects and provides definite and permanent lubrication. The pen carriage *P* is driven by a lead screw, both the screw and the sliding contact J being geared to shaft H, so that there is no dependence on friction elements. Another interesting feature—unique in the field of electrical recorders—is automatic compensation for expansions and contractions of the chart paper due to variations in humidity: in the first place, all charts are printed on a standardized paper stock in an atmosphere of constant humidity; and each instrument is equipped with a pen-position corrective mechanism which is actuated by a strip of the same standardized paper. Another feature is that the galvanometer is enclosed in an inside compartment with a glass window, protecting it when the recorder door is open. Multiple-record instruments are equipped with a "color code" print-wheel device (instead of the

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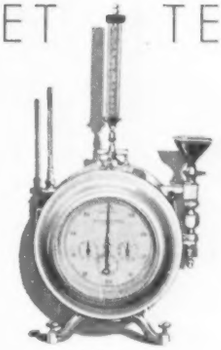

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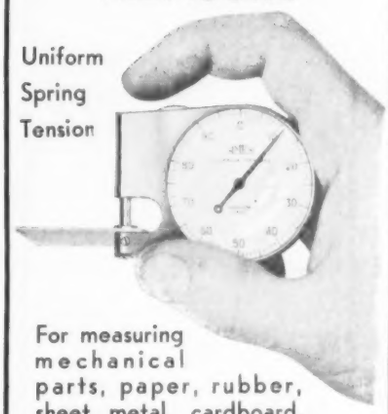

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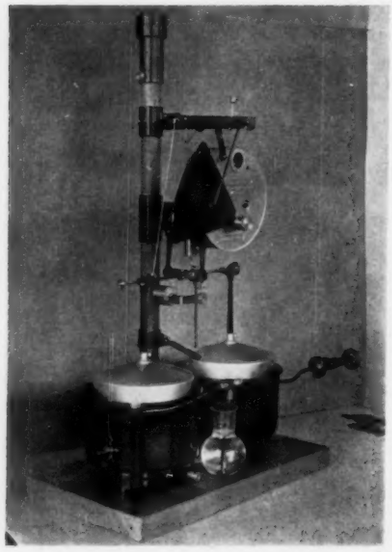

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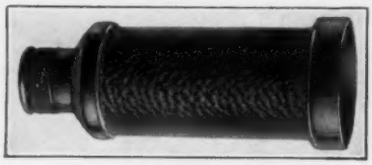

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pen P shown in Fig. 41-29) which the makers originated, whereby confusion among several records close together is prevented. Several automatic control models of this recorder are available, each providing a distinct mode of control.

(d) Cambridge

The Cambridge Instrument Co.'s own "Potentiometric Recorder" is of the mechanical-relay type, and must not be confused with the "Callendar" electrical-relay recording potentiometer or bridge (described in Section 2) which is also of Cambridge manufacture. The mechanical-relay instrument has been modified considerably in recent years, and at the time of writing (February, 1935) the only complete description of the latest mechanism to which the authors could have access is U. S. Patent 1,940,834 issued December 26, 1933. Fig. 41-31 is reproduced from this patent. A modification of the usual principle is used: instead of the pointer itself being clamped during a portion of each

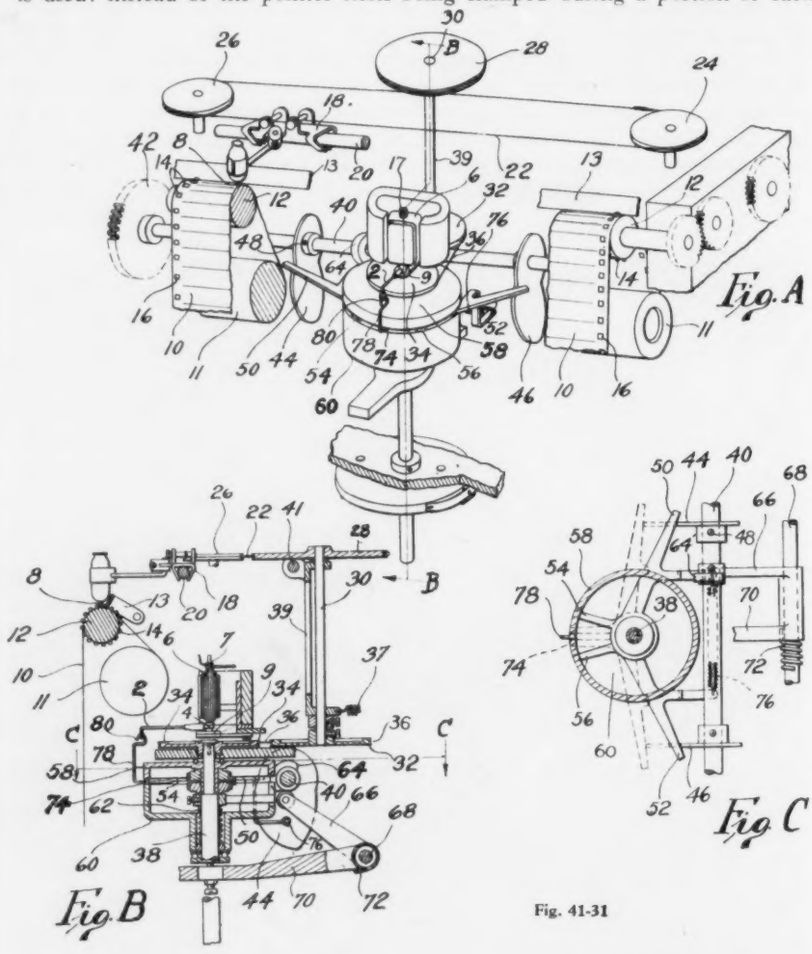

Fig. 41-31

cycle, it is ball 74, suspended from the tip of pointer 2, which is periodically clamped. Pointer 2 is so arranged that there is no strain on the galvanometer pivots when the ball is clamped.

Shaft 40, constantly rotating at a speed of 8.5 r.p.m., carries cams 44, 46 and 64. Cam 64, through levers 66 and 70, periodically raises cup 60, clamping ball 74 between this cup and cup 58. Both cups are keyed to shaft 38 so that when they clutch ball 74, any rotary motion imparted to ball 74 causes the whole clutch assembly to rotate. Cams 44 and 46 bear on scissors levers 50 and 52 which are pivoted on shaft 38, making their ends 54 and 56 approach ball 74 while it is clamped. If the ball is at the center, 54 and 56 meet at this point, both touching the ball, and no balancing action ensues. If the ball, in its clamped position, is on either side of neutral, either 54 or 56 brings it back to central position and in so doing, 54 or 56 will rotate cups 58 and 60 and shaft 38. After reaching the center, the scissors levers move apart and cam 64 causes cup 60 to release ball 64, allowing galvanometer pointer 2 to take up a new position.

When the clutch assembly is rotated, it rotates the sliding contact of the circular slide wire (not shown) which contact is attached to lower end of shaft 38; it also rotates (through pulleys 34 and 32 and belt 36) shaft 39

whereby the pen is re-positioned; and it also rotates the galvanometer coil by returning the pointer to zero. The clutch assembly and the galvanometer are arranged co-axially in tandem, so that even if, under unusual conditions, the clutch assembly should be rotated through a considerable angle, no harm can come to the galvanometer for the forces involved are not greater than the torque and the counter-torque present when the pointer of any moving-coil measuring element is immobilized while current flows through the coil.

4. Electronic-relay Types

(a) General Electric—Photoelectric

In the photoelectric recorder brought out in 1932 by the General Electric Co. the basic measuring unit may be a millivoltmeter coil or almost any type of sensitive direct-deflecting element. This unit carries a small mirror which directs a beam of light through an optical system upon a pair of photocells included in the servomotor circuit. The recording unit, which carries the pen, is in the nature of an iron-cored electrodynamometer, having its field winding permanently excited by rectified current. A mirror attached to the recording member forms a part of the optical system as explained below.

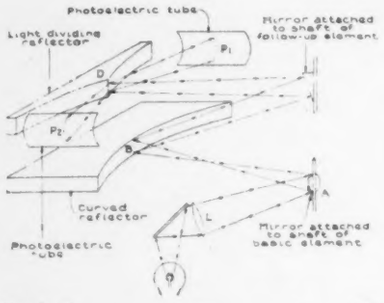

Fig. 41-32

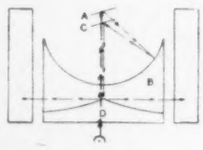

Fig. 41-33

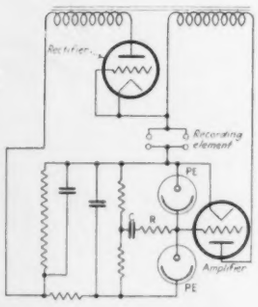

Fig. 41-34

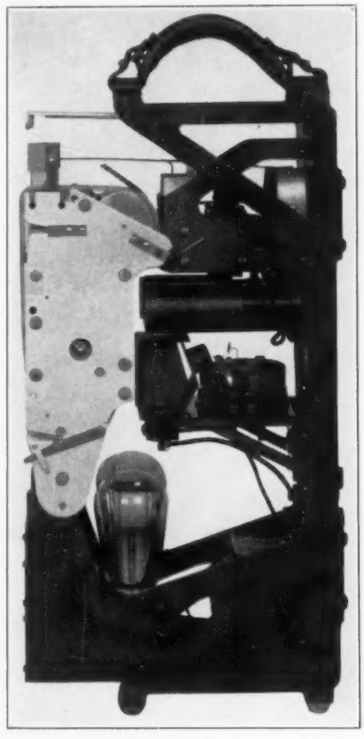

Fig. 41-35

Figs 41-32 and -33 are schematic diagrams of the optical system in perspective and plan. The lamp and condensing lens converge a source of light upon the basic element mirror *A*, from which it is reflected to curved mirror *B*, and thence to mirror *C* mounted on the recording member and in the center of curvature of mirror *B*. The point at which the light strikes *B* will depend upon the deflection of the basic instrument. Regardless of where it strikes *B*, however, it is reflected to *C*. The angle at which the light leaves *C* will depend upon the angle at which it arrived from *B*, and also upon the position of the recording member. When *C* and *A* are parallel the light beam from *C* will split evenly upon the dividing edge *D*. This holds regardless of the actual positions of *A* and *C*; the only requirement being that they be parallel. This will be apparent from a study of Fig. 41-33, in which the mirrors are shown slightly displaced from their true relative positions to permit tracing the path of the light beams. It will be seen that the two photocells will be equally illuminated only when the rotating mirrors are parallel.

The electrical circuit, including the two photocells, is shown in Fig. 41-34. In the circuit are two 3-element vacuum tubes of usual construction, one of which operates as a rectifier and the other as a control tube. The rectifier tube passes a constant half-wave current through the moving coil of the recording element in a direction to force the pen down-scale. The control tube passes a

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similar current through the coil in a sense to force the pen up-scale. The value of the latter current is determined by the grid potential on the control tube; and this, in turn, is governed by the relative illuminations on the photocells. When the recording element is in the correct position relative to the basic measuring element, the combined action of the two moving mirrors, as explained above, divides the light between the photocells so that the opposed currents in the recording element are balanced and the pen remains at rest. Beside the recording of practically all electrical magnitudes, including system frequency, this form of instrument has found a wide application in providing continuous records of temperatures and of illumination intensities.

(b) Westinghouse—"Pilotel"

Originally designated as the Westinghouse Electronic Recorder when brought out in 1933, this instrument is definitely called "Pilotel" by reason of its principle being employed in a Westinghouse telemetering system.

This instrument will record d.c. millivolts and microamperes at energy levels of 4 or 5 microwatts. A d'Arsonval mechanism in combination with a rectifier makes possible the recording of alternating currents with full scale values as low as 0.5 ma. Alternating voltages can be recorded in the same manner with one volt full scale and a potential circuit resistance of 500 ohms per volt. Fig. 41-36 is a schematic diagram of the recorder. It consists essentially of:

1. The primary, or measuring element which may be any usual type indicating instrument mechanism.
2. The pilot element attached to the measuring element.
3. The pilot element at the pen mechanism.
4. The motor element for driving the recording pen and for carrying the second pilot element coil.
5. An amplifier for furnishing reversible driving power to the pen motor.

The primary element is mechanically connected to a pilot element which comprises a moving coil mechanism rotable in an a.-c. field. This field is provided by a stationary electromagnet connected to an auxiliary controlling circuit. The moving coil of this pilot element is connected in series with the moving coil of the duplicate pilot element which is mechanically connected to the pen-driving motor. The stationary fields of both pilot elements are connected in parallel to the same a.-c. source. Their moving coils are connected in series opposing each other. When these coils do not occupy corresponding positions in the a.-c. fields, the voltages induced in the coils are not equal and the output voltage at the input terminals is of a value depending upon the value of this difference. This voltage is of the order of 50 millivolts per degree deflection. The output of these coils is connected to the grid of the amplifier tube of the power amplifier unit. The a.-c. output of the amplifier is the same frequency as the pilot element excitation.

The pen-driving motor is essentially a 2-phase motor of which one phase is continually energized from the same source of power as the pilot element electromagnet coils. The phase position of the current in the other phase of the motor is determined by the relative positions of the pilot coils which determine the polarity and magnitude of voltage of the amplifier grid and as a consequence the a.-c. output of the amplifier. With the second phase of the pen-driving motor connected to the amplifier output, the motor will turn in a clockwise or counterclockwise direction at a speed proportional to the differ-

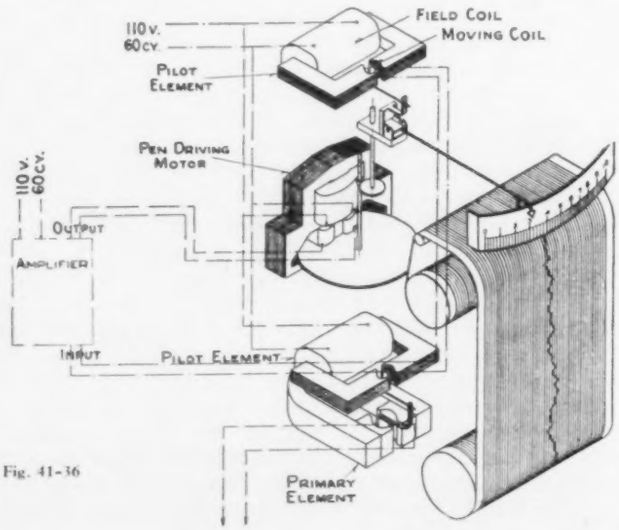

Fig. 41-36

ence in the pilot coil positions. This results in a proportionate response action of the pen motor. This motor turns in one direction or the other until the difference in pilot voltages is zero, thus using a null method. It therefore is unaffected by the characteristics of the vacuum tubes.

Under normal conditions it requires 1 second for the pen to travel from zero to full scale with an overshoot of approximately 2%. By increasing the time to 1.25 seconds, the recorder can be made dead beat.

(c) Tagliabue

Developed for industrial pyrometry, the Tagliabue electronic-relay recorder was definitely placed on the market in 1934 but it had been publicly exhibited in 1932. Its principle is that of photoelectric balancing, a beam of light from the galvanometer mirror to a photocell being interrupted by right and left shutters operated in synchronism with contacts in the servomotor circuit, and the photocell not being a calibrated element but serving only to detect the direction of the light beam—to detect whether the galvanometer is at the null point or deflected right or left.

The opening before the photocell is divided by means of right and left shutters of offset outline, Fig. 41-37, into five effective areas, *a*, *b*, *c*, *d* and *e*, *c* being the center. These shutters are raised and dropped alternately by right and left cams, which, with a power cam, operate three sets of contacts. A relay closes when the light beam from the galvanometer strikes the photocell, and opens when it is cut off by a shutter. Thus, if the light is in area *a*, raising the right shutter will not cut it off but if it is in area *b*, raising this shutter will let it strike the cell, and cut it off when the shutter drops. The right and left contacts are closed while both shutters are down, ready to stop the contact carriage when the light beam swings into area *b*, *c* or *d*. The power contact is closed only while one or the other of the shutters is closed. At this time only one of the left and right contacts is closed.

If the light is in area *a* the contact carriage (and the light beam) start to the right. The conditions for this are (1) relay closed, (2) left contact closed and (3) power contact closed. These conditions are met only while the right shutter and the relay does open. This results in the conditions (1) relay open, when the shutter drops, but if it is in *b* the light is cut off by the drop of the shutter and the relay doesopen.Thisresults in the conditions (1) relay open, (2) left contact closed and (3) power contact open; and the carriage stops. Thus, when the light is in *b* the carriage takes a short step. When it is in *a* it will not stop because the conditions for stopping it are not fulfilled until it reaches the end of the scale. They are not fulfilled while the *left* shutter is up, because at this time the left contact is open.

Finally the light beam swings into area *c* and the relay remains open. In Fig. 41-37 *c* is shown bounded by two edges of the shutters slightly off the center line. These two edges of the real shutters are coincident on the center line and a virtual area *c* results in this way: When the light beam is at the center, and one shutter rises, half the light reaches the photocell, which is insufficient to cause the relay to close, but if the light is slightly off center and more than half the light reaches the cell, the relay may close. The necessary amount off center is half the width of the virtual area *c*.

The complete balancing power-circuit is shown in Fig. 41-38. The carriage is driven by Telechron motor *RM*, the field coils of which are connected to the contacts of two motor relays *MR*. These a.-c. relays are operated by the simultaneous closing of the power contact, one of the left and right contacts

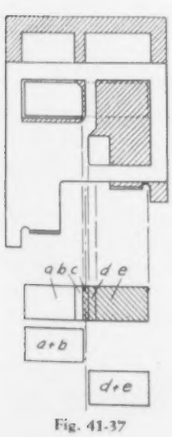

Fig. 41-37

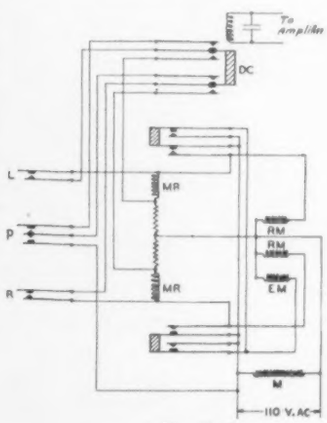

Fig. 41-38

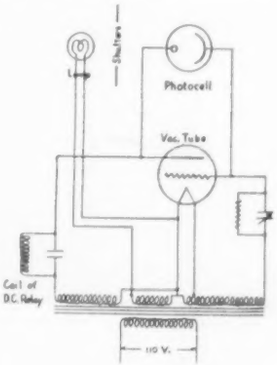

Fig. 41-39

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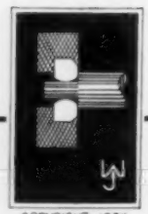

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and the d.-c. relay repeatedly mentioned as "the relay" in the preceding paragraphs. The motor relays are wired to stay closed until their coils are short circuited. This accounts for the continuous travel of the carriage as long as the light beam is in area *a* or *e*. They both are connected also to the coil of an electromagnetic stop *EM* which is lifted when the motor starts and engages a toothed wheel when the motor is disconnected.

The photoelectric circuit is shown in Fig. 41-39. The photocell is connected directly from plate to grid of the vacuum tube, the grid circuit of which includes a small adjustable condenser shunted by 70 megohms. The plate circuit includes the d.-c. relay coil shunted by a condenser to smooth out the intermittent direct current. The lamp and the tube filaments are directly connected to low voltage sections of the secondary of the transformer. The adjustable condenser is employed principally as a factory adjustment to care for the characteristics of the tube, cell and lamp, and occasionally by the user to care for widely abnormal line voltage.

The recording and commutating mechanism serves to turn the multiple switch, depress the print wheel, and occasionally connect the standard cell. The mechanism is locked inactive while the contact carriage is traveling from one recorded temperature to the next, and is released by the opening of electromagnet *EM*. Fifteen seconds after this a record is made and the switch and print wheel turned. During these fifteen seconds, ten or fewer (as needed) steps are taken to bring the contact to the balance point. Once in every 120 records (30 to 60 minutes) a switch disconnects the thermocouples and connects the standard cell, causing the mechanism to record the standard current. The standard instrument is wired for twelve thermocouples with convenient means for connecting fewer. A cycle of twelve temperatures is ordinarily completed in about five minutes. Charts are 11 inches wide with a 10-inch scale. The galvanometer is completely enclosed. A special feature is its platinum-gold alloy suspension of particularly high tensile strength.

(d) Leeds & Northrup—"Speedomax"

In the Leeds & Northrup "Speedomax" (1933) the balancing mechanism of the earlier L & N instruments (see Section 3) is replaced by an electrical system which greatly increases the speed with which the recording member reaches its final position. The potentiometer (or bridge) method of measurement is retained, but the device is unique in that *there is no galvanometer*. Instead there is introduced into the thermocouple circuit a carbon microphone actuated by an armature from an a.-c. source. This acts as a "chopper" and modulates the unbalanced d.-c. emf in the thermocouple circuit. This circuit includes also the primary of a transformer, whose secondary feeds an amplifying system embodying a pair of opposed grid-controlled rectifier tubes controlling the exciting windings of a split-field motor. In operation the unbal-

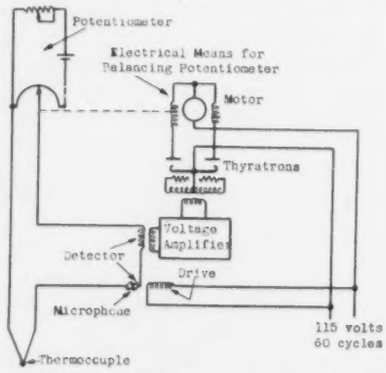
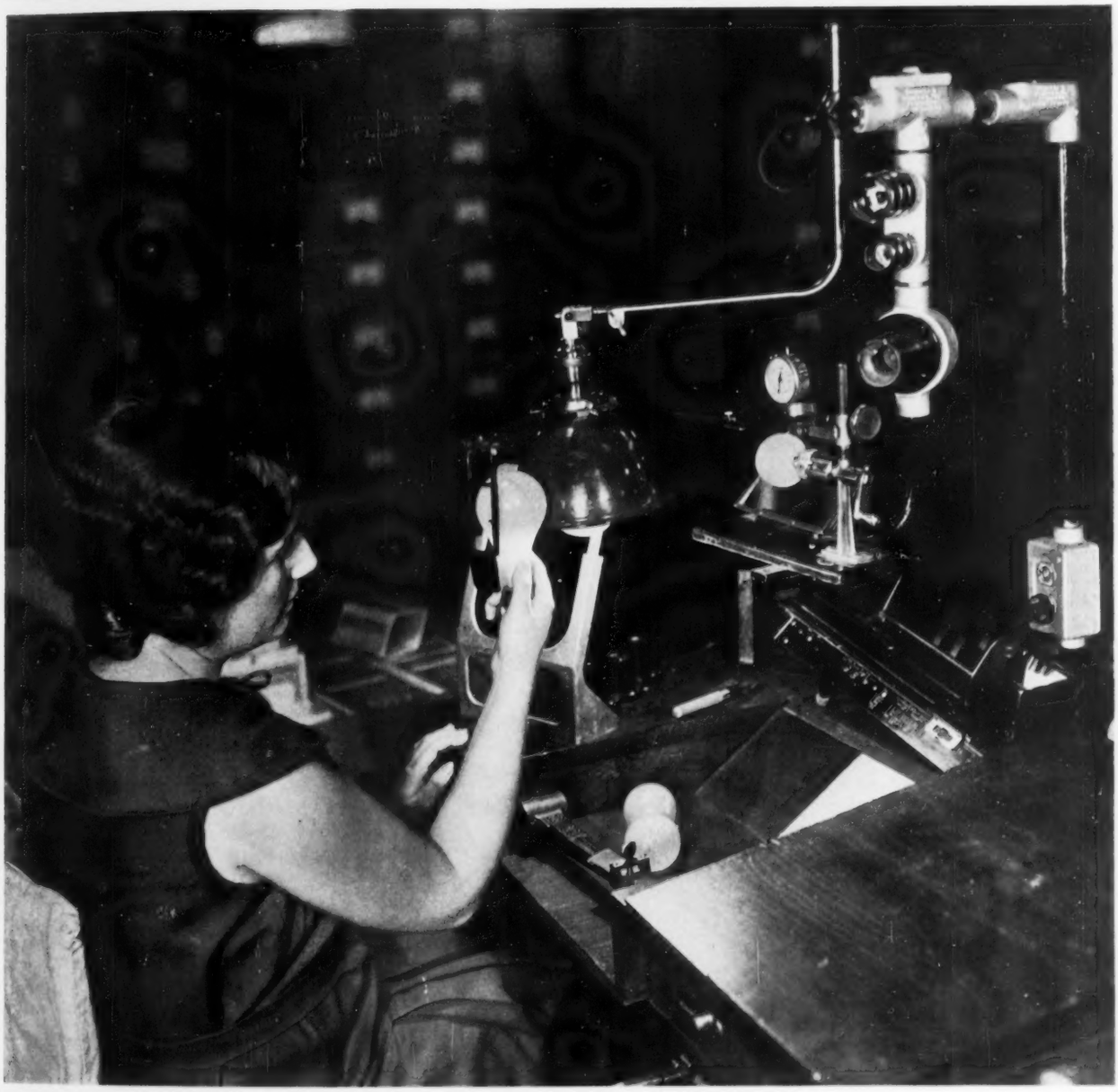


Fig. 41-40

anced emf in the thermocouple circuit is modulated by the microphone, giving an a.-c. component in the primary of the transformer. The phase-position of this voltage is determined by the direction of flow of the unbalance current before modulation; and, since the action of the tubes is governed by the phase position of the grid voltage, the motor is made directly responsive to the unbalance in the potentiometer system, and rapid restoring action is secured. Any tendency to overshoot is eliminated by the use of a small magneto directly coupled to the motor and opposing its emf to that of the thermocouple circuit. It is claimed for this instrument that a chart width of 10 inches can be covered in two seconds without overshooting. A simplified diagram of the measuring and control circuits (omitting the magneto) is shown in Fig. 41-40, and a photograph of the instrument appeared on page 11 in the January 1934 article of this series.

INSPECTION and TESTING



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(Courtesy General Electric Lamp Co.)

A "Proving Ground" for Telephone Cords

Laboratory Tests Which Concentrate Years of Normal Service Into a Few Weeks Are Invaluable in Determining Design Features Which Make for Durability Under Severe Conditions

By K. W. GRAYBILL*

TELEPHONE cords present far more problems to challenge the ingenuity of the design engineer than are evident to the casual observer. Cords are not only subject to usage under almost every imaginable condition of atmospheric moisture and dust, but are also frequently abused by careless handling. The actual destruction of cords by abusive treatment constitutes one reason why expensive construction features cannot be used in the design of cords.

Some of the more common characteristics of cord construction are so well known that they will either be merely mentioned or neglected entirely in the discussion to follow. For example, the "tinsel rope" conductor used in flexible cords is so well known that it needs no detailed description here. It is sufficient to point out that many years of experience, aided by comparatively recent improvements in the metal alloy and the form of metal ribbon used, have provided a tinsel rope that is practically free from trouble. The insulation of the tinsel with silk, which is in turn impregnated with an asphalt compound and covered with an outer braid of cotton, is ordinary practice in cord construction, but the exact procedures followed and the exact materials used can be varied to produce great differences in the insulation resistance between conductors and in other cord characteristics. The arrangement of the individual conductors in the cord assembly, as well as the material and structure of the outer braid, affect the flexibility of the cord, its insulation resistance and its resistance to abrasion.

The most favorable conditions for each of these variables can only be determined by careful and thorough laboratory tests. A comprehensive series of tests of various cord construction practices was carried out by Associated Electric Laboratories, Inc. It is thought that a description of some of the methods used may be of interest to those in other branches of industry.

Telephone cords must be softly flexible; must withstand repeated flexing without breakage or kinking; must maintain high insulation resistance between conductors even under conditions of continuously high relative humidity; and must resist abrasion of the outer covering resulting from contact with surrounding objects. For obvious reasons, artificial and accelerated tests must be conducted to disclose the value of proposed methods of construction.

The insulation resistance between conductors of a cord must be high to avoid unnecessary transmission loss and interference with supervisory or control operations of the central office equipment. Tests to disclose insulation resistance are conducted by exposing the cords to an atmosphere of approximately 98% humidity at a temperature of 95°F., and measuring the leakage between conductors by means of a galvanometer with 100 volts d.c. applied. A typical humidity tank for such laboratory procedure is shown in Fig. 1, and the galvanometer setup is shown in Fig. 2. Accurate results from such a test are possible only when precautions are taken to avoid condensation of moisture on the cords by providing adequate control of the "atmosphere" and suitable suspension for the cords.

The quality and purity of materials used and the manufacturing processes by which these materials are assembled into the individual conductors are of the utmost importance in obtaining high insulation resistance. The straight, parallel assembly of conductors without any filler material provides a slight advantage as compared to the twisted assembly including fillers to produce a cord of very round cross-section. Even the material and construction of the outer braid is a factor of some importance in securing high insulation resistance between conductors. Improved insulation characteristics have been obtained by combining the most advantageous of these conditions.

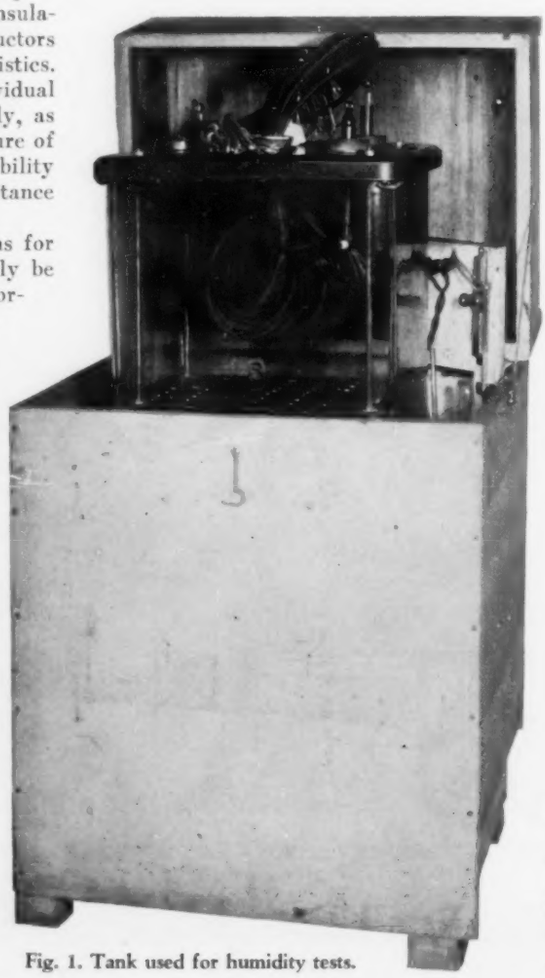


Fig. 1. Tank used for humidity tests.

Telephone cords must be flexible enough to avoid inconvenience to the telephone subscriber. Too soft and flexible a cord will ordinarily have a comparatively short life. Another characteristic related to that of flexibility is the objectionable tendency to form permanent "kinks." Flexibility and the tendency to kink were examined qualitatively by merely handling cords; they were tested in the field by placing cords in service on telephones used by critical observers; and they were determined quantitatively in the laboratory by measuring the force required to kink a cord around a certain diameter of brass tubing. In this latter test, the brass tubing was slotted and a record was made of the pull required on one end of the cord to just close the slot, as illustrated in Fig. 3. To make this

*Engineer, Associated Electric Laboratories, Inc., Chicago.

test of value it is necessary to choose a brass tube of such diameter, wall thickness and width of slot, that the major part of the pull exerted is that required to kink the cord rather than close the slot. Almost every detail of cord construction is a factor in determining the flexing and kinking characteristics of a cord. The material used, the tightness of wrappings or braidings, and the position in which the conductors are assembled, are examples of important factors determining these characteristics. The straight parallel placing of conductors combined with the materials and construction practices selected for "Monotype" cords produces desirable flexibility accompanied by an unusual degree of resistance to permanent kinking.

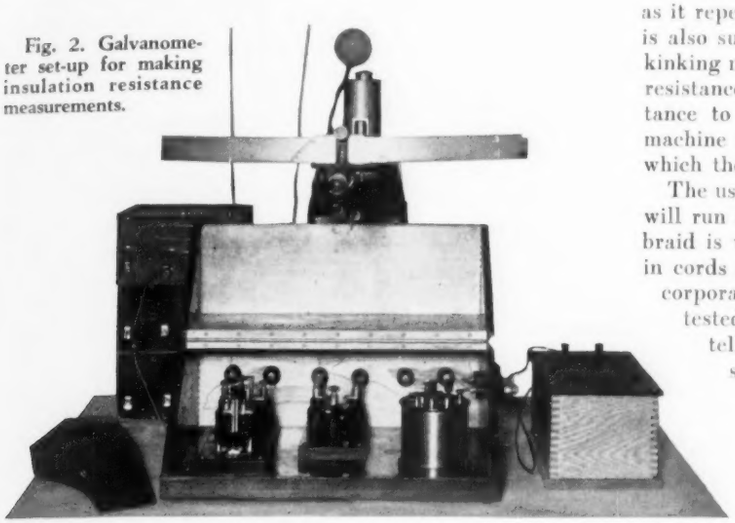


Fig. 2. Galvanometer set-up for making insulation resistance measurements.

Forcible kinking of a cord is one form of abuse in service that is frequently encountered. It was considered desirable to determine what construction characteristics offer greatest resistance to failure under such abuse. The test machine illustrated in Fig. 4 was used to kink and unkink cords of different designs repeatedly to obtain such information. It serves also as an acceptable method of judging the strength and wear resistance of outer braids and conductor braids, as well as serving as an auxiliary apparatus during insulation resistance tests.

Merely testing cords for insulation resistance after exposure to high humidity is not considered sufficient. The regular test procedure alternates periods of exposure to humidity with periods of flexing in the machine shown in Fig. 5. This flexing tends to open up impregnating material and insulation somewhat as actual service will and this tends to disclose weaknesses in design which result in low insulation resistance.

The outer braid of a cord is subject to frictional wear as it repeatedly rubs against a desk or other objects and is also subject to breakage due to kinking. Tests in the kinking machine in Fig. 5 are helpful in determining the resistance to breakage from this source. Tests for resistance to abrasive wear are conducted on the type of machine illustrated by Fig. 5. It rotates a drum against which the cords are held with a fixed load or pressure.

The usual measure of life is the number of hours a cord will run on this test before a single strand of the outer braid is worn through. A number of different materials in cords of original design as well as the materials incorporated in cords of prominent manufacturers were tested on this machine. While the above discussion tells in a few words the procedure followed in selecting the design features of the "Monotype" cord, it does not adequately indicate the time and effort necessary to achieve the final result. Engineering studies such as this proceed for months with a great deal of painstaking testing and recording of data, additional hours of careful analysis of data, and occasional disappointments in the results of test procedures which make useless many days of effort. It is typical that an engineer persists stubbornly to struggle with such tedious detail and disappointments, knowing that in the end he will be satisfied only with an honestly superior product.

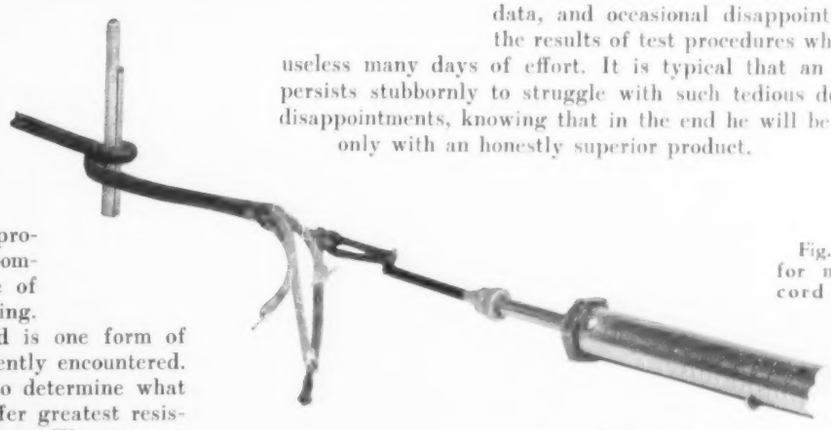


Fig. 3. Device for measuring cord kinking force.

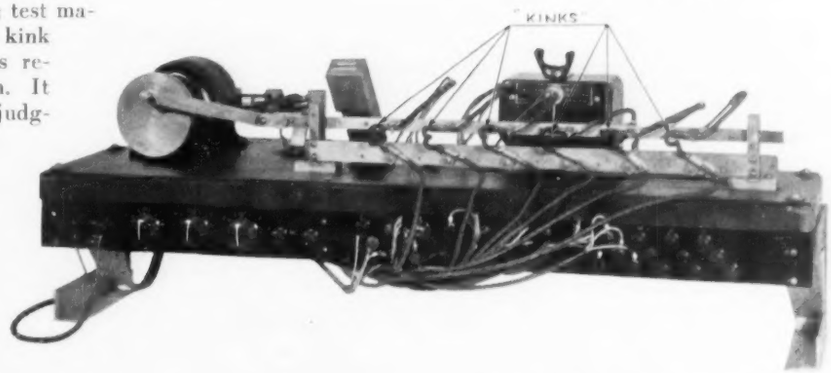


Fig. 4. Machine for testing resistance of cords to wear under kinking conditions.

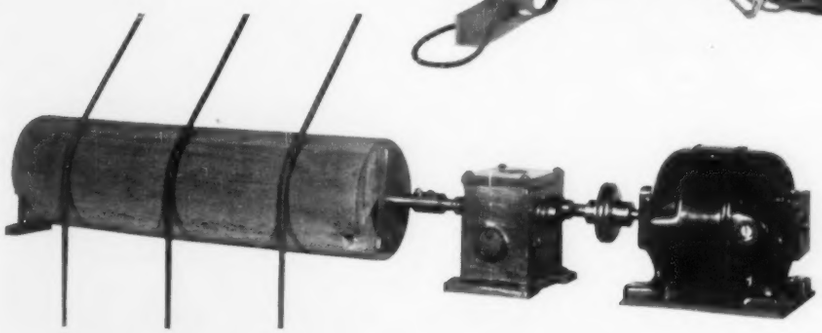


Fig. 5. Device for testing for abrasive wear.

Materials Testing Machines

An Account of Their Development, with Special Reference to the Tension-Compression-Transverse Group

By C. H. GIBBONS*

PART FOUR

Similar machines are described by Unwin[36] and called the "Thomasset"[54] machines,[34] of which he stated that[36] "probably the Thomasset machine is in some degree the parent of the great machine at Watertown," which is to be described at some length later in this account.

About the same time (1868) Capt. James B. Eads as Chief Engineer of The St. Louis Bridge Company, was building the St. Louis Bridge over the Mississippi at St. Louis, Mo. In numerous respects this structure pioneered into new fields of engineering achievement. Captain Eads realized that the materials entering into the bridge must be made to pass rigid tests in order that the project reach a successful conclusion. He, therefore, had built two universal testing machines, both of which merit attention; the smaller because of the strain measuring equipment, and the larger because it was the largest (in point of capacity) testing machine in the world. The first, of 100 tons capacity (Fig. 22), was built in 1869 by Shickle, Harrison & Co., St. Louis, and was installed at Main and Green Streets, St. Louis, Missouri. The other was of 800 tons capacity (Fig. 23), built by Keystone Bridge Co., Pittsburgh, Pa., and was installed early in 1871 at the plant of William Butcher Steel Works, Philadelphia (later Midvale Co., Nicetown, Philadelphia), who had the contracts for the supply of the steel entering into the main compression members of the bridge and for the supply of certain very heavy couplings for service in connecting the compression members to one another.

As may readily be seen in the cut, the 100 ton machine employed a hydraulic ram $7\frac{1}{4}$" in diameter for load production and for strain compensation, and a lever system for load measurement, water being used in the latter in place of the usual metal weights. Pressure was supplied by a hand pump. The strain gage was optical in principle, having a rotating steel pin which carried a

*Baldwin Southwark Corp., Philadelphia, Pa.

[54]M. H. Thomasset was a manufacturer of hydraulic presses in Paris and exhibited his testing machine at the International Exposition in Paris in 1878.

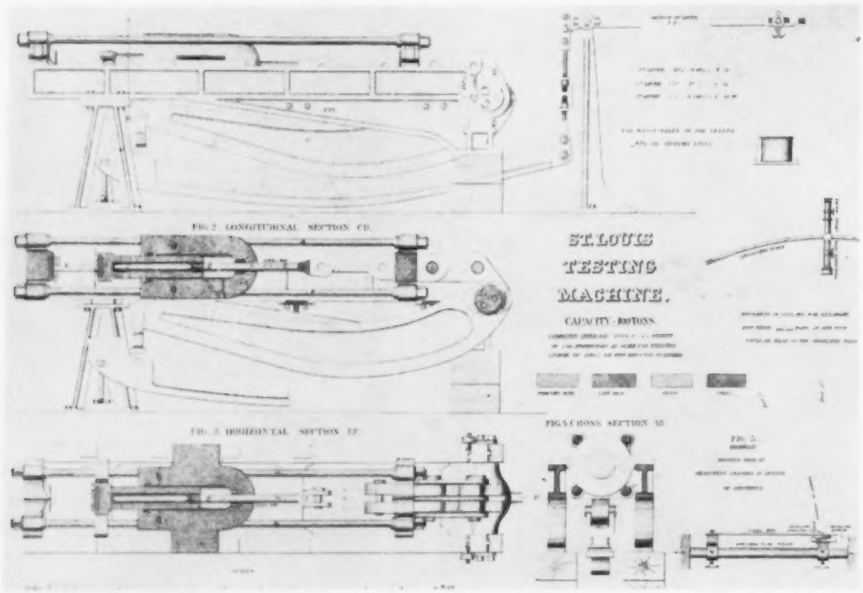


Fig. 22. The Testing Machine of Colonel Eads, designer and builder of the St. Louis bridge in 1868.

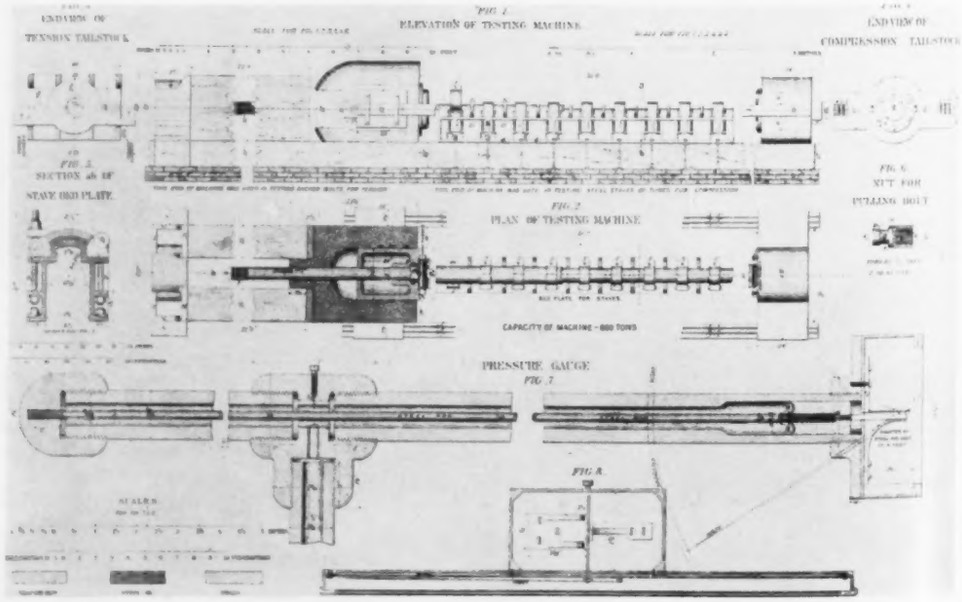


Fig. 23. Another Testing Machine built for Colonel Eads and used in testing materials for the St. Louis bridge. This machine was installed in the plant of the Midvale Company, Philadelphia.

small mirror. Extension or contraction of the specimen caused a motion of the two collars relative to one another. This motion was converted into a rotary motion of the pin by the means which may readily be seen. A graduated scale at a 25-foot radius from the mirror as a center was viewed through a telescope with cross-hairs. The movement of the collars was magnified 2,400 times so that a movement of 0.00001" or less could be read.

The 800-ton Philadelphia machine employed a hydraulic ram 24" in diameter for load production and for strain compensation, but because the physical size and weight of such a lever weighing system was beyond the reach of industry at that time, load measurement was effected by an ingenious pressure gage, also shown in the cut. This gage (by means of a long light hand on a roller between two surfaces which moved relative to one another, as may be seen) measured the elastic extension of the $^{3}/_{16}$" diameter measuring rod, which, having been previously calibrated, indicated load on the specimen; calibration was effected on the St. Louis machine, the ratio of cylinder areas being such that the hydraulic pressure in the Philadelphia machine was less than that in the St. Louis machine.[55]

About 1870 Riehle Brothers built a testing machine (Fig. 24) of 40,000 lbs. capacity. The frame was of oak timbers and was about 9 feet high, the machine weighing complete about 2,000 lbs. The design had been so changed from the original machine that the jack was now mounted at the bottom and operated downward. The load was transmitted upwards by means of a yoke, which may be clearly seen. The foot treadle returned the ram of the jack to the initial position in readiness for another test. The weighing means was an ordinary scale beam or steel-yard. It had a unique device, however, in the form of an automatic weighing device. A container was hung from an ordinary spring balance, which, in turn, was secured to a rod depending from the scale beam. As the hydrauiic jack loaded the specimen and the scale beam rose, the motion of the latter opened a trap door in the container fixed to the frame and allowed shot to run into the container below. This restored the balance. When the specimen broke, the quantity of shot in the lower container was noted and its weight added to that of the cast iron weights to secure the breaking load of the specimen.[56]

Throughout this decade (1870 to 1880) numerous testing machines, both vertical and horizontal, were built by Riehle Brothers to the designs of their superintendent, Tinius Olsen,[57] who had associated himself with Riehle Brothers at the request of Frederick A. Riehle. Among these machines was a 300,000-lb. horizontal, 130 feet in length, the bed of which was of timbers.[58] It was built for Bradlee & Co., Empire Chain Works, Philadelphia, and was used by them primarily for the testing of chain.[59] Numerous patents were secured by Olsen late in the seventies, among them being improvements in testing machines themselves and new forms of tools for holding the specimens.

About 1879 Olsen severed his connection with Riehle Brothers and founded, in 1880, a testing machine business of his own. The business prospered and by 1890 had grown to proportions approximately those of Riehle Brothers. In this period Olsen built numerous testing machines, both vertical and horizontal.[60] A typical early Olsen testing machine may be seen in Fig. 25.

Colonel Maillard,[34] for use in the French arsenals, modified the Thomasset idea (previously referred to) in the elimination of the lever and in the increase in size of the diaphragm so that the entire load could be absorbed in the weighing cylinder. A Maillard type testing machine at the Ruelle Foundries had a diaphragm of about 2,750 mm. (108") in diameter.

(To Be Continued)

[55] C. M. Woodward, A History of the St. Louis Bridge, 1881.

[56] *Journal, Franklin Institute*, Third Series, No. 63, May 1872.

[57] *Journal, Franklin Institute*, Third Series, No. 65, 1873, page 145.

[58] *Journal, Franklin Institute*, No. 108, 1879, page 38.

[59] This machine is in service still (1934). It bears the name plate of Tinius Olsen and Company, and both Riehle and Olsen claim it. The probability is that it was built in the Riehle shops by Tinius Olsen shortly before the latter severed his connections with the former.

[60] *Journal, Franklin Institute*, No. 131, 1891, page 81.

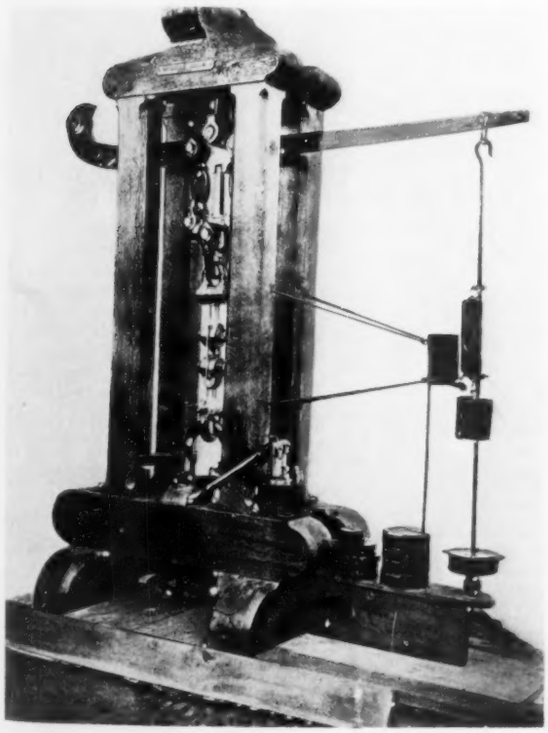


Fig. 24. An early Riehle Testing Machine, about 1870.

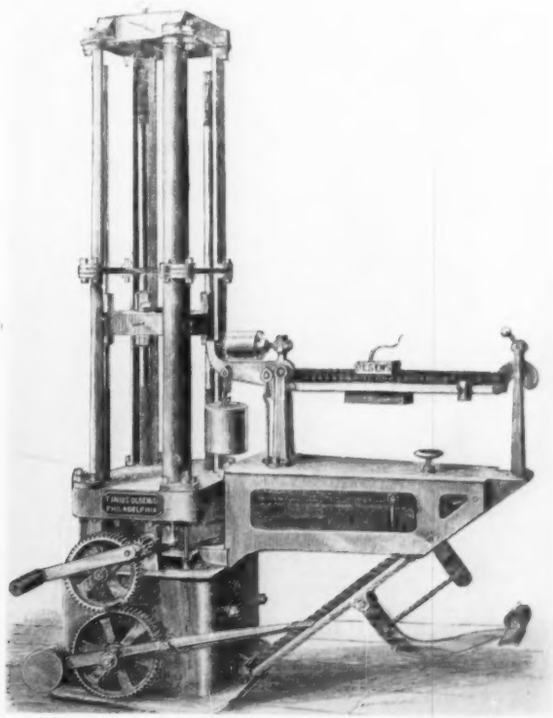


Fig. 25. An early Olsen Testing Machine, about 1891.

(*Continued from page 33*)

the duplication of any equipment or its adaptation to other needs.

It is remarkable that so many of the applications are so simple and free from technical complications. A complete list of the processes described would be too extensive for a review. With the use of light-sensitive devices automatic counting, illumination control, sorting, color analysis and safety promotion appliances represent several of the score or more devices disclosed. The regulation of time intervals, speed control, automatic relays, current control, and other interesting projects are accomplished with gas-filled triodes, such as thyratrons, grid-glow tubes and the like. High gain amplifiers adapted for the frequencies encountered in manufacturing processes, and used for many types of measurement and inspection are described.

The study of motions with stroboscopic illumination, electron devices in chemical analysis, combustion studies, cathode ray oscillographs are likewise taken up. There is hardly a field of industry that is not represented.

This book is recommended to every executive who is interested in improving production and inspection methods and in reducing costs; to industrial and production engineers to point out modern methods of making rapid routine checks and non-destructive tests at points where production problems occur; to radio and electrical engineers to call attention to the possibilities for additional revenue in this rapidly expanding field; and to experimenters interested in setting up useful—shall we say—"gadgets" such as door openers, automatic drinking fountains or some of the numerous other automata usually called "robots" and "tin wizards" by the press.

The last statement should not be misinterpreted, for the author has collected the data judiciously and has been able to sift out freakish stunts. Numerous bibliographical notes are included referring to original sources of information. By far the greater part of these references refer to American publications, such as *Instruments* and *Electronics*, insuring that no reference is difficult to obtain, and also that the tubes and other parts used are readily obtainable in this country.

Descriptions are given of all electron tube types that are industrially useful: amplifier, rectifier, thyratron, high-vacuum, mercury-vapor, grid-glow, oscillator, cathode-ray, X-ray, photoelectric, voltage and current regulating, etc.

The book is well illustrated with photographs and circuit diagrams. It is a pleasure to recommend a book so admirably prepared and timely in its scope. RALPH R. BATCHER (5.3)-B-

The Hardness of Metals and Its Measurements. By HUGH O'NEILL. Chapman and Hall, Ltd., London, 1934. Cloth, 6¼ x 9¾ inches, 292 pages. Price 25s.

Here is a book of 292 pages devoted exclusively to the hardness of metals and its measurement. In this respect it is a pioneer volume and a distinct contribution to that subject. One reads the book with the assurance that he is sitting at the feet of an authority in his subject. Anyone who has kept up with the literature of hardness measurement, will recall many papers bearing the name of O'Neill. This is not a book which the average man, running the routine hardness tests in a shop, will read as a guide to testing. Rather it is a compendium for the professional metallurgist.

The author has divided his book into nine well balanced chapters. One could wish that the Introductory Essay on Hardness in general might have been elaborated. It is excellent so far as it goes and is the sort of discussion needed to clarify our concepts of the property of hardness. However, Dr. O'Neill believes that he should devote the most of his space "to a detailed consideration of the various methods which have gone to build up the hardness testing edifice." This he has done in a masterly fashion. First he spends considerable time on "Features of Some Static Indentation Tests." Chapters 1 and 2 comprise this general topic. Chapter 3 discusses the various instruments commonly used for static and dynamic indentations. This technical side of the subject is then followed by

NEW INSTRUMENTS

In this department we strive to report each month ALL the new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions.

When writing to manufacturers directly, please mention this department as your source of information.

Or write to information Section, Instruments Publishing Company.

Universal Fluid Meter

Designed to measure any fluid under any industrial conditions, new Universal Meter enables user to meet special requirements without paying for special design, and completes Foxboro Co.'s line of fluid meters of the head class. New mechanical integrator built especially for this meter, registers quantity on 5-digit cyclometer (1), operates without cams, may be supplemented by pen (5) which records predetermined increments on

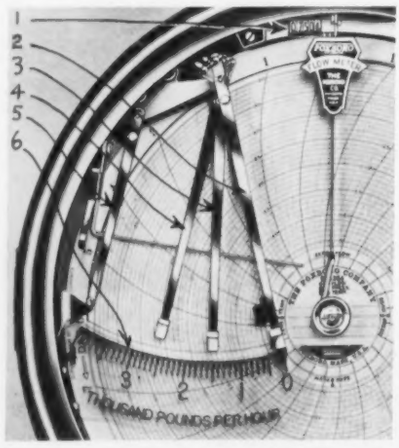


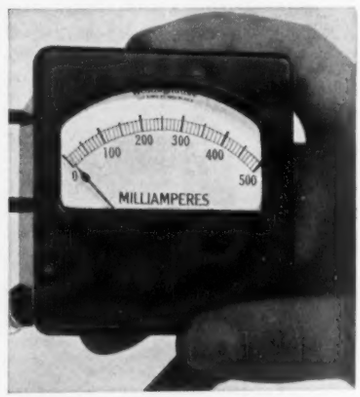
chart rim. Unusually large range of readable flows—described as flow rangeability of 10 to 1—is said to make new meter combine "rangeability advantages of two separate meters." Automatic compensator for variations in static pressure is embodied in meters intended for applications where these variations would vitiate flow records and quantity registrations based on uncompensated line pressure. In addition to flow-rate pen (2) and to quantity pen (5), two additional recording elements—for pressure (3) and for temperature (4) may be embodied in meter; also a transparent scale (6) for indication of flow rate. Flow-rate scale is uniform, permitting use of charts uniformly graduated in terms of rate, pressure and temperature. Pens of multi-record models are coaxially pivoted, cannot interfere with one another. Standard Foxboro check-valves protect meter from over-range flows and from incorrect manifold valve manipulation. Zero is checked positively and accurately. Damping can be adjusted while meter is in service.

Circular Slide Rule

For business rather than engineering purposes, "Commercial Calculator" brought out by Tavella Sales Co. has six concentric scales and two transparent arms. Inner scale is years, next is months and days, the two forming a perpetual calendar for problems involving interest rates. Other scales aid price computations. Diameter 5".

Miniature Instruments

Radio-frequency, d.-c. and Rectox miniature instruments are announced by Westinghouse Electric & Mfg. Co. Only one large hole in panel is required. All visible mounting screws are eliminated by using mounting clamps. Soldering clips are standard for electrical terminals. New "RX" instruments have a scale length of 2.4" and are accurate to 2% (Rectox types 5%). Flange dimensions 3"x3⅛" with zero adjusters on outside. Dull matte Moldarta cases. Numerous refinements are said to have been made in the design of the d'Arsonval movement such as: soft iron pole tips welded to permanent magnet in accurately aligned fixtures; improved springs; new method of supporting iron core in a die-cast bracket which also supports jewel bearings in alignment. Provision is made for use of extremely strong cobalt-steel magnets for super-sensitive microammeters. Permanent magnets are of heat-treated and aged tungsten steel or cobalt steel. Construction features



assure "extremely accurate air gaps with convenience of removal of moving element from pole pieces as a complete unit for easy repairing." Uniform scale distribution except when used with thermocouples or Rectox units. Range of ratings available:

DIRECT CURRENT

Ammeters	—1 to 8 amperes
Milliammeters	—1 to 800 m.a.
Microammeters	—20 to 800 microamps.
Voltmeters	—1 to 5000 volts (200 ohms per volt)
Voltmeters	—1 to 1000 volts (1000 ohms per volt)

RADIOFREQUENCY

Ammeters	—1 to 8 amperes
Milliammeters	—100 to 800 m.a.
External thermocouples	—1 to 50 amperes

RECTOX

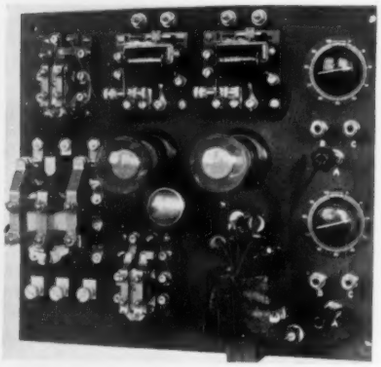
Microammeters	—200 to 500
Milliammeters	—1 to 10
Voltmeters	—4 to 150 (1000 ohms per volt)
Voltmeters	—1 to 3 (2000 ohms per volt)
Voltmeters	—½ to 1 (5000 ohms per volt)

Hardness Testing Machine With Microscope

Convenience, speed and elimination of personal errors were objects sought for in designing new "Diamo-Brinell" tester brought out by Pittsburgh Instrument & Machine Co. Operation being simple, skilled technicians are not required. Indenter is a diamond pyramid, producing well-defined square impressions. These are measured on diagonal—a method said to make for precision—by special measuring microscope with easily-read counter, accuracy being to 0.001 mm. Load application, through a system of weights and levers, is automatically timed. To make a determination, test piece is raised until it nearly touches indenter point and motor starter is pressed with foot: operation begins and ends automatically. (If test piece was not brought close enough to indenter point, however, a buzzer will sound.) Impression having been made, stage is lowered, microscope is swung over, reading is taken and reference is made to charts (furnished) which give official Brinell Scale number.

Automatic Repeat Timer

For control of electrically-operated devices and machines requiring automatic timing of "power-on" "power-off" periods, The Electric Controller & Mfg. Co. announce Automatic Repeat Process Timer, in four standard sizes, designed for operation on 110, 220, 440 or 550 volt circuits of any standard frequency.



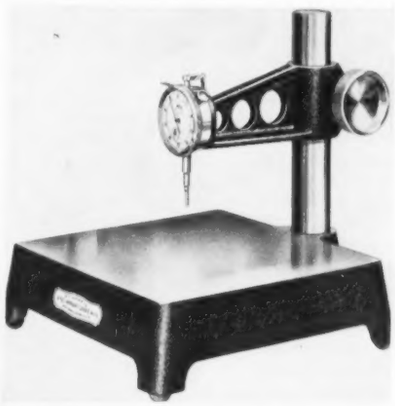
Operates on principle of time required to charge a condenser. Both "on" and "off" periods are independently adjustable. Each can be adjusted from 0.05 sec. minimum to 0.90 sec. maximum on the smallest size of timer. With both periods set at minimum time, timer will provide 550 operations per minute. With the largest size of timer, the "on" and "off" periods are adjustable between 0.12 sec. minimum and 7.5 seconds maximum. Timers can be supplied with different ranges of time for "on" and "off" periods. Illustration brings out the independent adjusting dials.

Electrical Instrument Parts and Accessories

To enable users to effect economies both directly and through greater convenience, the Weston Electrical Instrument Corp. has placed on the market a wide range of its standardized parts and accessories including: one-to six-deck rotary switches with 12 to 36 points; 12-position uni-polar and 10- and 24-position bi-polar switches; push-button and toggle switches; bar handles for rotary switches; 18 different resistors and 10 shunts; various portable mounting bases; multi-range scale plates; batteries; fuses; various assemblies of cables and leads with different plugs or terminals, etc., etc.

Dial Gage Mounting

Changes in mounting announced by B. C. Ames Co. were made to support dial gage more rigidly and to provide a quick and positive clamping of bracket to column. Cast iron base has ground top surface 8″ x 8″. Bracket is especially rigid, brings gage to center of ground flat, is securely fastened by a slight turn of large binding screw. Gage regularly supplied is 2-1/16″ diam., has a movable dial graduated 0-50-0 in thousandths, and



a small hand to indicate number of revolutions made by large hand. Spindle is raised 3/10″ by pressing down lever at left. Other Ames gages can be used. Maximum width 8-5/8″; depth 8″; height 11-3/16″. Capacity to measure up to 5-15/16″ with the gage regularly supplied. Net weight 16½ lbs.

A.S.T.M. Cloud & Pour Test Apparatus

A four compartment "cold test" apparatus to meet the latest A.S.T.M. Cloud and Pour Test specifications for lubricating oils is announced by C. J. Tagliabue Mfg. Co. These specifications require at least three, and preferably four, cold test baths which must be maintained at the following temperatures:

1—Temperature +30 to +35°F.
2—Temperature 0 to + 5°F.
3—Temperature —30 to —25°F.
4—Temperature —60 to —55°F.

Each compartment of new apparatus is copper-lined and insulated with 2″ cork on sides and bottom making it a separate cooling unit. Four metal jackets rigidly attached to a metal base, for each compartment, same as now supplied with the TAG single compartment apparatus. Removable Bakelite top. A mixture of solidified CO_2 and alcohol is used. Bath temperatures are maintained by adding from time to time a small quantity of solidified CO_2 to liquid in bath after minimum temperature has been produced.

the theoretical and practical relations between hardness on the one hand and cold working, crystallinity and heat treatments on the other. Chapters 4, 5, 6 and 7 are the most valuable in the book from the standpoint of learning what constitutes hardness. Chapter 8 follows with a discussion of the preparation and examination of the specimen to be tested. The final chapter deals with properties closely allied with hardness, such as abrasion, wear, cutting hardness and machinability.

The metallurgist sticks to his metals, the mineralogist to his minerals and the forester to his woods when discussing hardness. For a physical property which has attained such prominence as hardness has in the technical world, where "practice has outstripped theory," it would seem that it is about time for the physicist to generalize and bend some of his energies to this problem. Surely modern physics with its electronic theory of matter and the colloid theory has something to offer to the theory of hardness. Hardness can no longer be relegated to just one particular field. It is a universal property of solid matter.

S. R. Williams (2.10)-B-

Applied Acoustics. By H. F. Olson and Frank Massa. P. Blakiston's Sons & Co., Philadelphia, 1934. Cloth, 5½ x 8½ inches, 430 pages. Price $4.50.

A book on this rapidly developing subject will naturally meet with a wide interest among students and engineers The authors of this volume present the theoretical and experimental aspects of applied acoustics in a clear concise style, and with an abundance of pertinent details on certain problems which reflects their combined ten years of experience in an acoustical research laboratory.

In an introductory chapter the book develops the fundamental equations for plane and spherical waves starting from the basic continuity equations. There follows a mathematical treatment of dynamical systems of a single degree of freedom together with the steady state energy relations for systems of several degrees of freedom—developing in parallel the formulas for electrical, mechanical and acoustical systems and defining the analogies among them in such a manner that one who is familiar with the electrical or mechanical system theory gains readily a clear understanding of the functions of the elements of an acoustical system. From this point on the book becomes primarily descriptive, theoretical analyses being subordinated and being brought in only in brief form to augment the text. Fundamental acoustical measurements are described, followed by a detailed study of microphones, telephone receivers, and loud speakers of the various types in common use, together with methods of calibrating and testing. The subject of architectural acoustics is ably presented, including sound insulation, theory and measurement of reverberation, as well as its effects in broadcasting studios and theatres. Various methods of noise measurement are outlined. There are two tables of constants which will be of interest to the student and of particular value to the engineer since due to the fact that many of the data have been only comparatively recently determined, the information is not always easily available. A glossary of terms commonly encountered in the text is included. To complete a well founded treatment of the subject the book gives a short study of physiological acoustics.

Although a knowledge of differential and integral calculus is required for a full understanding of the subject matter of this book, the presentation is such that one may ignore the mathematical excursions, and without losing the trend of thought derive a good deal of usable information. The authors have seen fit to present the subject in such a way that the book is equally suitable as a text or reference. Perhaps those who will benefit most will be those engineers who know acoustics as it has been taught up to within the past few years, and who wish to keep up to date with recent developments and with the important strides made in applying classical theory to modern acoustical problems and apparatus.

R. M. Burley (6.1)-B-

MANUFACTURERS' NEW LITERATURE

In this department we list each month the printed matter issued by manufacturers. Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter are invited to do so.

C25 **Metallic Bellows.** Loose leaf folder describes the "Hydron" bellows (a hydraulically formed metallic bellows). Remote control of temperatures is discussed and vapor-pressure temperature curves of typical filling mediums are included. Clifford Mfg. Co., 564 East First St., Boston, Mass.

C26 **Graphic.** Bulletin No. 934 (a house organ) contains a very interesting article "Power, Power Factor and Profits" which is an account of a graphic study of the plant of the United-Carr Fastener Co., Cambridge, Mass. Esterline-Angus Co., Indianapolis, Ind.

C27 **Automatic Temperature Control for the Home.** Leaflet illustrates this new conception of an automatic temperature control. Penn Electric Switch Co., Des Moines, Iowa.

C28 **New Spectrographs.** 8-page bulletin illustrates the small Littrow spectrograph for industry and education. Bausch & Lomb Optical Company, Rochester, N. Y.

C29 **Balanced Combustion Control System.** 8-page Bulletin No. 8 is an illustrated technical description of a fuel-and-air ratio control system wherein the master fluid pressure is a function of the plant load and each individual fuel regulator responsive to two pressures. Brooke Engineering Co., Inc., 175 W. Huntingdon St., Philadelphia, Pa.

C30 **Indicator Flowmeter.** Bulletin E-3 is attractively printed and fully illustrated with diagrams for various types of installations. It is published in the new 8½"x11" size for adaptation to the company's loose-leaf binder which has been recently introduced. American Meter Co., 60 East 42nd St., New York City.

C31 **Electric Counters.** Circular illustrating features of Wizard electric counters. Production Instrument Co., 1315 South Wabash Ave., Chicago, Ill.

C32 **Glass & Ceramic Filters.** A book in German "Glas-und Keramische Filter" by Dr. Paul H. Prausnitz contains information on filtration problems, extraction, gas distribution, dialysis, etc. The price of the volume is $5.00 and can be obtained from Fish-Schurman Corp., 230 E. 45th St., New York City.

C33 **Portable Hot Cathode Ray Oscillograph.** Bulletin 1110a, in English, briefly describes construction and applications of this type instrument. Trüb, Täuber & Co., Zurich 10, Switzerland.

C34 **Varidrive Motor.** Bulletin illustrating this new development in motor design can be obtained from U. S. Electrical Mfg. Co., 203 East Slauson Ave., Los Angeles, California.

C35 **Relay.** Leaflet illustrates and describes relay for use with photo cell control apparatus. Electronic Products Co., St. Charles, Ill.

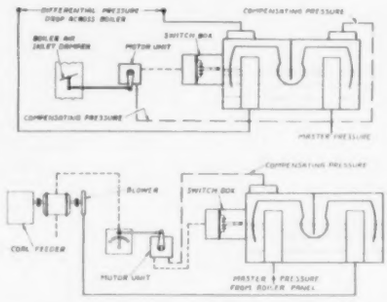
C36 **Pyrometer for Small Diesels.** Leaflet A-3410 describes the Thwing Type JR pyrometer for Diesel engine exhaust temperatures and for general industrial applications. Thwing Instrument Co., 3339 Lancaster Ave., Philadelphia, Pa.

C37 **Hydrometers.** This 4-page folder describes 3 new instruments: the Aquatron shows at a glance, the concentration of salts in solution in any water over a temperature of 70° to 120° F. and at any concentration from 0 to 1000 grains per gallon; the Pyknotron determines suspended solids in water, temperature range 70°-120° F., concentration range 0 to 100 grains per gallon; the A. P. I. Thermotron shows exact gravity of any petroleum to an average accuracy of 0.1°. Stromberg Motoscope Corp., 2130 Lawrence Ave., Chicago, Ill.

C38 **Microscopes & Accessories.** 174-page catalogue of microscopes and accessories for the biological sciences. W. Watson & Sons, Ltd., London, Eng.

Combination Control System

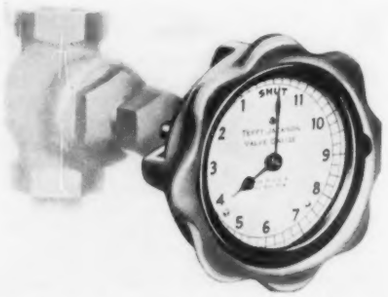
In new Fuel-Air-Ratio system of combustion control developed by Brooke Engineering Co., air flow through boiler is measured by pressure drop across last two passes, and fuel feed by the air pressure from a small blower driven by feeder mechanism. Air and fuel pressures are balanced independently of each other against a common master pressure. This master pressure also is low-pressure air. Quantities of air and fuel fed to a boiler are thus measured, balanced



against each other, and at same time are instantly responsive to changes in the master pressure, *i.e.* plant load. No compressed air is required, all power being furnished by small electric motors at each point of control. Small duplicate motor-driven fans are furnished back of the master panel. As there are no pilot valves or air bleeds at individual regulators, and as low-pressure air is used in master system, response of motor units to unbalanced conditions is said to be as quick as that of the ordinary draft gage. Individual boiler panels are furnished in addition to the master panel. The system may be applied to either stoker, pulverized coal, oil, or gas firing.

Valve Position Indicator

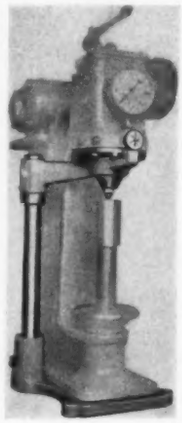
Tells at a glance how many turns open or what proportion thereof. Operates by a gravity mechanism, making it applicable to stems in horizontal or semi-horizontal position. Makers, Tefft-Jackson, Inc., state that same setting will give same result each time valve is operated.



Indicator is adjustable in its own bracket which replaces regular valve wheel, enabling resetting when valve wears or when new seat and disk are installed. When both hands are at "shut" the valve is closed; when small hand is at "1" and large hand at "shut" the valve is one turn open, and so forth. A number of sizes are available. Special attachment may be had for large valves, rising stem valves and overhead chain-operated valves.

Direct-reading Brinell Attachment

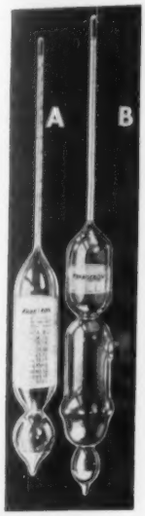
Of interest to those doing extensive Brinell testing is an attachment announced by Detroit Testing Machine Co. This device in conjunction with a Brinell machine (power-driven or hand-operated) enables operator to check hardness of parts or specimens without use of a microscope. In most cases grinding or spotting is said to be unnecessary and equally good results obtained on flat, rounded or odd surfaces. Tolerance hands are set to desired limits and operator merely notes whether or not pointer stops between them. Indicating instrument is supported independently and errors due to frame deflection or distortion are said to be entirely eliminated. A degree of accuracy "hitherto unattainable" is claimed for this arrangement, which also makes device adaptable to all makes of machines. A rate of 600 tests per hour is possible under favorable conditions. Actual test made is standard Brinell determination which may be checked at any time with the microscope.



Rapid Blueprinter

A blueprint machine which utilizes the new "Angstrom" blueprint lamp is announced by Milligan & Wright Co. Lamp used costs 25c to replace, is of incandescent type; operates from 110-115 volt d.c. or a.c. supply without need of transformer choke coils, etc.; differs from ordinary incandescent lamp in quality of light produced, being stronger in blue end of spectrum. Model 100 illustrated is portable table type which will print 18 x 24". To make a print place tracing and paper on plate glass top, lower pressure pad and close cover. Automatic time switch is usually set for about 1 minute exposure (length depends on speed of paper). When time switch clicks off, print is removed and washed in trays provided, and dried on special drying board also furnished. It is said that machine can be operated by anyone without danger of accident or fire.

Special-purpose Hydrometers



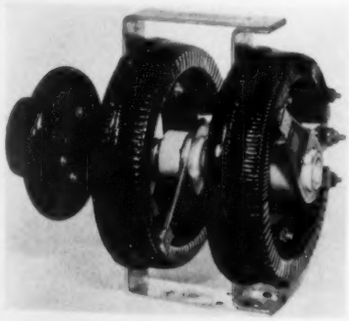
Three new hydrometer sets (including total-immersion open-scale thermometers, jars and plush-lined cases) are announced by Stromberg Motoscope Corp. Two are for boiler water: "Aquatron" set including Fig. A, hydrometer is for saline concentration, 0 to 1000 grains per gallon readable to ±5, within temperature range 70° to 120°F. "Pyknotron" (B) outfit is for suspended solids up to 100 grains per gallon, 70° to 120°F. The "A.P.I. Thermotron" is a set of 8 hydrometers for petroleum oil gravity.

Lance Form Pyrometers

Handled miniature millivoltmeters scaled for temperature-emf relation of standardized thermocouples are announced by Russell Electric Co. under designation of "Hold Heet Pyrometer Lance." In addition to welded insertion couple illustrated, there are also available couples consisting of two straight pointed rods; also surface-contact form with junction in a silver disk.

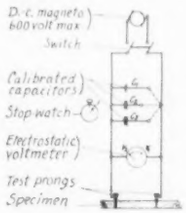
Tandem Co-axial Rheostats

Two or more rheostats are so arranged that they require no more panel space than does a single one, in a series of new units announced by Ohmite Mfg. Co. Each individual rheostat is adjusted by a separate knob or handwheel. Knobs and wheels may be moved together when it is desired to keep same relation of settings. "Tapered" rheostats are available, consisting of several sections, each of a different size wire. A common application is control of small a.-c. generators.



Moisture Meter

Portable and self-contained, the new "timing method" moisture-content determination outfit brought out by Trüb, Täuber & Co. is particularly designed for testing wood specimens, for which work a standardization certificate by the (Swiss) Federal Materials Testing Lab. is furnished on request. Normal accuracy



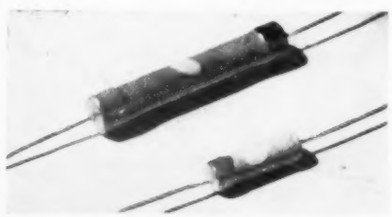
is 0.5% within moisture-content range of 3 to 18%. Tables are supplied for converting condenser discharge times to moisture-content for all well-known materials, also instructions on cross-grain and with-grain characteristics; special tables are made up for special materials. Circuit including three capacitors provides both a fairly long total range and high sensitivity within each scale range.

Self-illuminating Magnifier

Utilizing condenser principle, a new magnifying glass announced by K. G. Frank and styled The Inspect-O-Scope illuminates its own field to double the brightness of surrounding space; is said to be the only magnifier that gives a stereoscopic effect and preserves full color effect when used in daylight. Available in two styles: approx. 2½"ϕ and approx. 1¼" ϕ. Resolving power said to be superior to that of a conventional magnifier.

Crolite Resistors

Inexpensive extruded resistors are announced by Henry L. Crowley & Co. Novelty resides in production of a solid, homogeneous, full cross-section conduction body comprising a "background material" of high-resistance value, with a greater or less admixture of low value material to obtain desired resistivity. Entire cross-section is uniformly current-carrying, there being no conducting film or coating, no isolated conducting particles and no uncertain contacts between adjacent particles. New "Crolite Resistors" have a smooth, hard, black body, with a protective coating. Ends are coated with metal and capped with ferrules to which pigtails are integrally attached. Uniform diameter and length for usual range of standard resistance values and wattages. Color-coded if desired. Temperature co-efficient "practically negligible." A 1000-hour steam-box test for moisture variations showed change of <2%.



C39 **Gage Manual.** 32-page, loose-leaf book printed on heavy buff bristol illustrates and describes the precision products of the Sheffield Machine & Tool Co., Dayton, Ohio. It covers: visual gages, electric gages, plug gages, adjustable limit plug gages, ring thread gages, adjustable limit snap gages, length gages, etc.

C40 **Time Recorders.** Leaflet illustrates In-and Out Time Recorders, job-time recorders, program instruments, process timing and signalling instruments. Stromberg Electric Co., 223 W. Erie St., Chicago, Ill.

C41 **Elapsed Time Indicator.** Bulletin MI-4 illustrates an instrument whereby the duration of operation of a machine or device may be obtained. Stromberg Electric Co., 223 W. Erie St., Chicago, Ill.

C42 **Diamond Wheels.** 16-page booklet describes Norton Diamond Wheels for grinding and lapping the cemented carbides and hard brittle materials. Norton Co., Worcester, Mass.

C43 **Faster and More Accurate Inspection.** Four-page leaflet illustrating the adjustable length gage. Sheffield Gage Corp., Dayton, Ohio.

C44 **Portable Radium Detector.** Bulletin 2100 describes this instrument and discusses its operation for locating radium. American Instrument Co., Inc., Washington, D. C.

C45 **Photoelectric Relays.** Bulletin 150A illustrates and describes photoelectric relays for industrial and scientific use. G-M Laboratories, Inc., 1731 Belmont Ave., Chicago, Ill.

C46 **Color Comparator and Reflectometer.** List P27 discusses a diffuse illumination color comparator and reflectometer (Priest-Lange-Judd system) for the measurement of surface reflection, translucency, hiding power, color comparison and trichromatic analysis. Akatos, Inc., 55 Van Dam St., New York City.

C47 **Boiler Feed Control.** Northern Equipment Co., Erie Pa., has published an illustrated paper by E. G. Grady, plant engineer, on "Operating Experience at Masonite with High Pressure Boiler Feed Control." Folder No. 137.

C48 **Rheostat.** Four-page bulletin gives some pointers on rheostats and the specifications for Udylite rheostats. Udylite Co., 1651 East Grand Blvd., Detroit, Mich.

C49 **Vibrating-Reed Tachometers.** Bulletin 1390 describes principle of operation and construction, method of reading, mounting, ranges, etc. of Frahm vibrating reed tachometers. James G. Biddle Co., 1211 Arch St., Philadelphia, Pa.

C50 **Switchgear.** Catalog No. 8 contains 60 different illustrations of switchgear including: simple control panels; open and enclosed dead front equipment; cubicles; metaclad gear; switch houses and special equipment of many kinds. Roller-Smith Co., 233 Broadway, New York City.

C51 **High Speed Photo-Electric Pyrometers.** Bulletin 1101, 16 pages, describes and illustrates the new Tag potentiometers: photoelectrically balanced recorders, photoelectric controllers and light-beam indicators. C. J. Tagliabue Manufacturing Co., Park and Nostrand Aves., Brooklyn, N. Y.

C52 **Dark Field Optical Systems.** 16-page booklet lists equipments for dark field microscopy with a practical discussion of dark field optical systems. Bausch & Lomb Optical Co., Rochester, N. Y.

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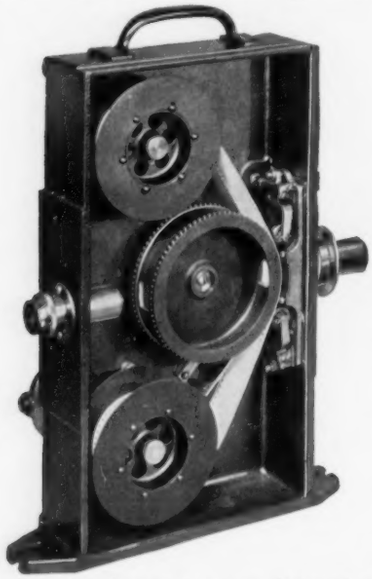
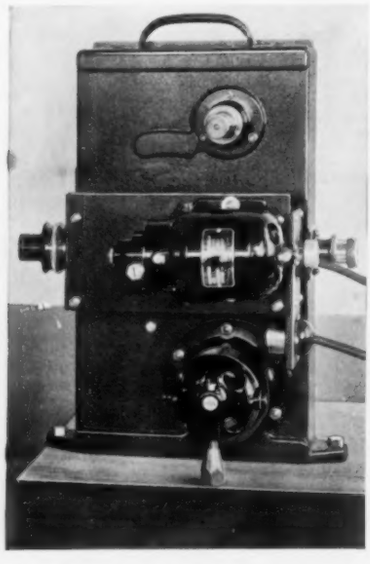
Moving-film Camera

Requirements for photography of transients with use of cathode-ray tubes, as well as those of high-speed photography using stroboscopic illumination, have suggested the characteristics of General Radio Co.'s new high-speed shutterless



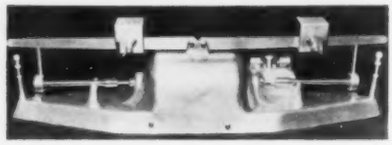
camera. Equipment has been designed to accord a wide flexibility of application. Camera unit proper consists of lens mounting and reels, together with a focusing eyepiece. Focusing is adjusted on the film by means of openings through the sprocket. Various types of motor equipment are available, giving a range of film speeds from about 1 to about 35 ft./sec. Two motors are normally used,



respectively driving the main sprocket and the take-up reel. The latter motor is a series motor of low power, designed to have just sufficient power to keep film taut, and so to adjust its speed to diameter of film on reel. This device eliminates need of a variable-ratio drive between driving sprocket and take-up reel. Magazine reel has a capacity of 100 feet. Normally 35-mm. perforated film is used, but camera can be adapted to 16-mm. film.

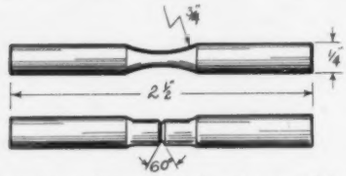
High-speed Repeated-stress Testing Machine

Developed to meet the demand for a rapid, dependable and inexpensive method of determining the endurance limits of metals, this new type high-speed repeated-stress machine announced by Glen N. Krouse is said to give test results comparable to those obtained with slower and more expensive machines. Investigators are said to have found that specimen size has no appreciable effect on endurance limits: same number of cycles will determine endurance limits at testing speeds of 10,000 r.p.m. as are required at slower speeds. In new machine, Fig. 1, two in-



dependent specimens, stressed as rotating cantilever beams, are driven by a direct-connected motor at 10,000 r.p.m. Each is held in a chuck on either end of the motor shaft. Other end of specimen is held in a chuck on one end of a bending arm, free end of which rotates in a shielded ball bearing carrying weight of one end of scale beam (directly above) carrying a movable weight and graduated in inch-pounds of bending moment. Only measurement necessary is that of diameter of reduced section of specimen. Stress in specimen is computed by the simple flexure formula. Stress cycles applied to each specimen are recorded on separate counters. When either specimen fractures, its counter is disengaged. Last specimen to fail stops motor. Toggle switch is provided for manual control. Two guards restrain bending arm after specimen has fractured. Dynamically balanced motor is designed for continuous high-speed service; operates on 110 volts a.c. or d.c.; is so rigidly mounted in main casting that sudden load release due to specimen failure does not affect stress in other specimen. Machine is 28″ long, weighs < 30 lbs., requires no special stand or fastenings.

Two types of specimens have been adopted which give important properties of metal under test. Endurance limit of a material, with surface finish approaching ideal, is seldom true measure of maximum usable stress under service conditions. Stress concentrations due to tool marks, holes and sharp notches are especially pronounced in some metals and should be considered in selection of a material where repeated stress is governing factor. Polished specimen, Fig. 2, will



give the endurance limit of a metal having almost ideal surface conditions, while notched specimen shows the susceptibility of metal to inferior finishes. Surface conditions in actual service lie somewhere between these two extremes. These two specimens are said to be easily and accurately machined from small amounts of metal, hence are inexpensive.

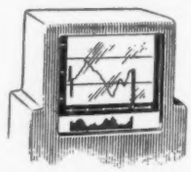
Electrodialysis Apparatus

An improved Mattson Cell, for laboratory use, is announced by the American Instrument Co. It consists of three U-shaped live rubber sections, closed by rubber end plates and separated by Cellophane membranes. Material to be dialyzed is placed in central compartment,

and direct current is passed between electrodes in outside compartment. Mobile ions in middle chamber are readily separated; many substances only slightly soluble, such as $CaCO_3$, are removed almost as quickly as soluble salts. Colloidal materials are freed of adsorbed ions and occluded salts, making method "ideal" for purification of many chemicals ordinarily difficult to prepare in pure form.

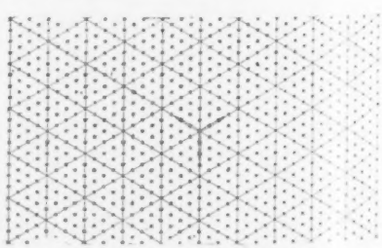
Stock Market Recorder

Produces daily double charts: on upper zone a curve is traced of instantaneous averages of 25 representative stocks; lower zone is bar chart of volume of trading in same stocks. Is not sold, but leased by Technigraph, Inc., which operates central station where reports are converted into electrical impulses actuating recorders on subscribers' premises. At central station, a new average is electrically computed and transmitted with every change of ⅛-point in any of the stocks, thus producing the upper chart; and sales volume is integrated over brief periods so that bars are traced on lower charts remote instruments at frequent intervals, tops of bars thus representing a rate curve. Before beginning of each trading session, range of previous day's market is recorded at left edge of fresh chart, thus affording continuous comparison.



Isometric Ruled Paper

For rapidly making isometric drawings a new paper is announced by Wade Instrument Co. It is printed green with all axes spaced 1″ apart and subdivisions of ¼″. A double-line "Y" shows center and isometric principle.



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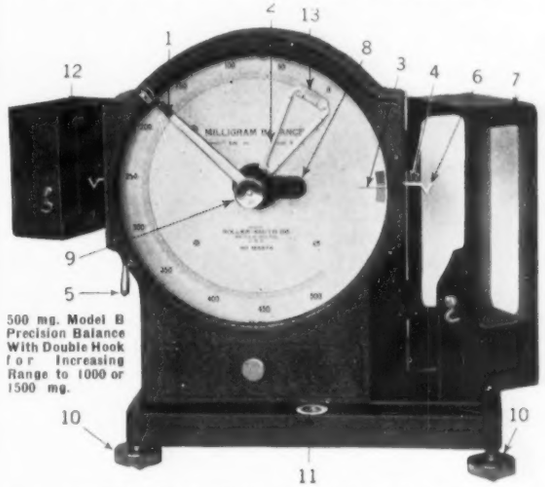

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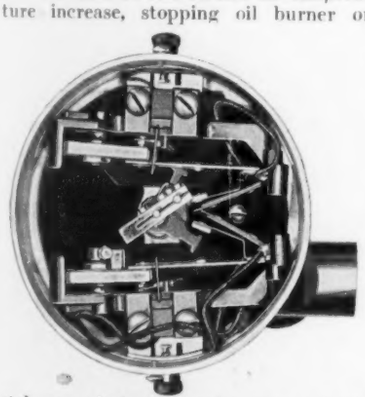
Detroit Lubricator Co.'s new combination fan and limit switch combines in one instrument a high-voltage fan control and high-voltage furnace limit switch, both of the 2-wire type. Fan switch is arranged to make circuit on temperature increase to start fan producing air circulation through ducts when setting temperature is reached. Limit switch breaks circuit on temperature increase, stopping oil burner or

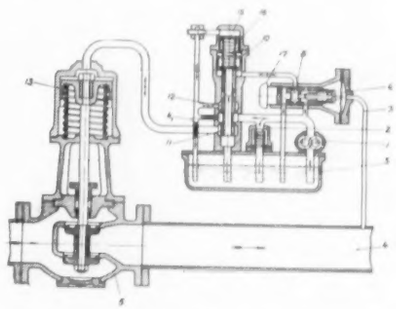


stoker, or closing gas valve when desired bonnet temperature is reached. It is normally installed in furnace bonnet or in plenum chamber. Both switches may be for high voltage, one for high and the other for low, or both for low voltage. Separate scales for fan setting and for limit control; adjustments arranged so that fan setting must always be lower than limit setting; differential adjustment on fan circuit provided inside cover for use where desired to change differential between cut-in and cut-out points of fan.

Pressure Control System

Originally designed to meet difficult automaticity requirements in Ruths Steam Storage Co.'s own installations, new "AVA Governor" has now been made available separately. This system is said to work without hunting even under most difficult conditions. Illustration is schematic diagram of system arranged as a reduced pressure controller. Electric motor driven gear pump 1 supplies oil pressure for power of servomotor, and relief valve 2 maintains oil pressure constant. Pressure in 4 (which is to be controlled) acts on diaphragm 6, movement of which is transmitted directly to double-acting amplifier valve 8 which controls oil pressure operating amplifier piston 10. This piston is integral with servo-motor pilot valve 11 and compensation pilot valve 12. Pilot valve 11 determines movement of servomotor piston 13 which operates main governor valve 5; pilot valve 12 on the other hand controls movement of compensation piston 15 which, by means of spring 16, acts on amplifier piston 10. Equilibrium is obtained when pilot valves 11 and 12 are in their neutral position as indicated in diagram. The two restrictions K_1 are so dimensioned that a balance is then obtained between compensation piston 15 and amplifier piston 10. At the same time, amplifier valve 8 is in its intermediate position. This corresponds to a definite deflection of diaphragm 6. Therefore, steam pressure in main 4 may readily be adjusted by changing relative position between amplifier valve 8 and diaphragm 6. Adjustment is accomplished by turning wheel 17, which can be done during operation.

Operation. Assuming for example an *increase* in steam demand in low-pressure main 4, pressure in main tends to decrease, causing diaphragm 6 to deflect to right. Amplifier valve 8 reduces pressure under amplifier piston 10, which then moves downward under the action of its spring. Servomotor pilot valve 11 opens and admits pressure oil to servomotor



13, thus opening main valve 5. At the same time, compensation pilot valve 12 relieves pressure oil from the space above compensation piston 15, thus reversing movement of amplifier piston 10. Pilot valves 11 and 12 are subsequently returned towards their neutral position and the movement of servomotor 13 comes to a stop. In this way, over-regulation and hunting are said to be positively prevented.

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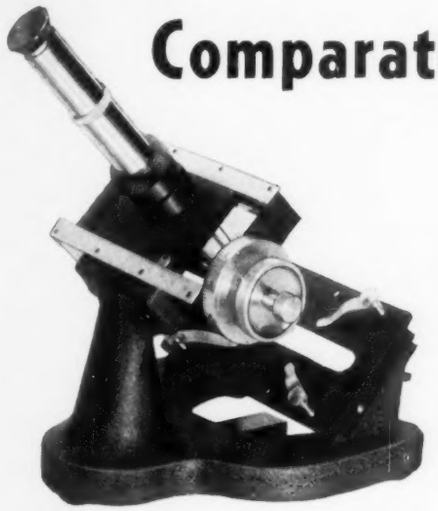

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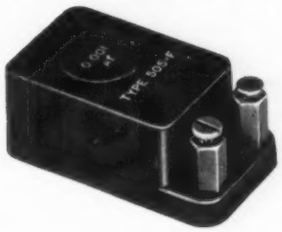

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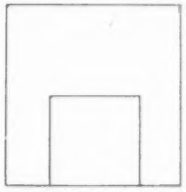

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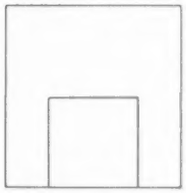

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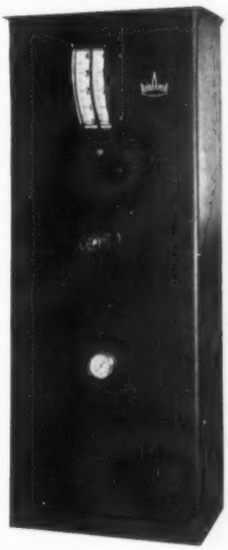

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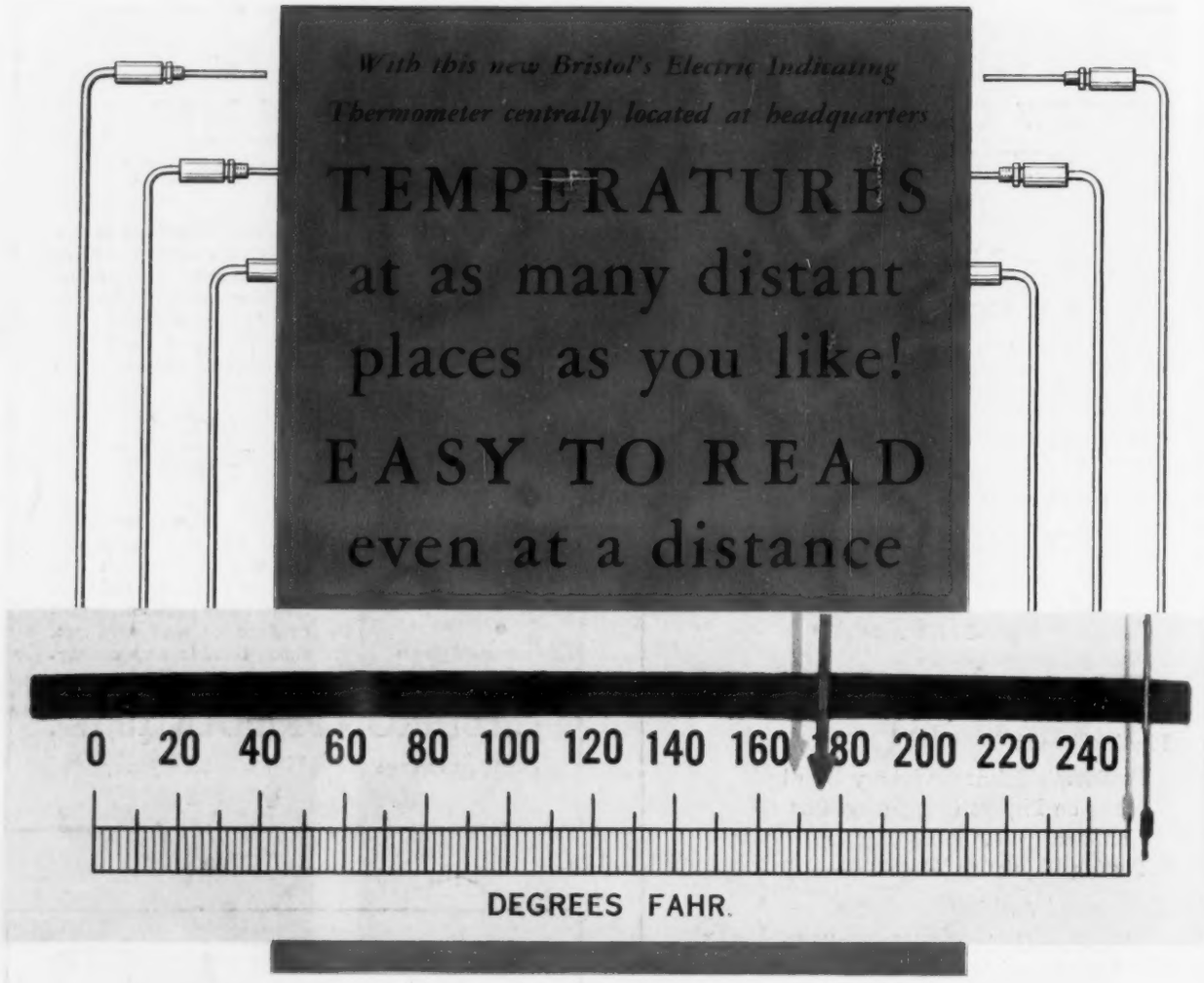
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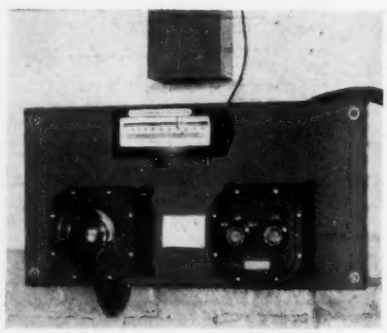
Reproduction to exact size of the extra wide scale in Bristol's Electric Indicating Thermometer

IF in the old days you wanted the temperature in a cold storage room, office, grain bin or other place, the chances were you took a mercury-in-glass thermometer and went out and got it. Or, if there were several such places, a separate thermometer was located at each one; and every so often somebody would make the rounds and read the temperatures.

In its time this practice was satisfactory. Under certain conditions it still is today. But in accuracy and convenience, it cannot be compared with the new Bristol's Electric Indicating Thermometer.

Accessibly installed at a central headquarters, it indicates the temperatures at any number of distant points. It does so with a precision conforming to the highest standards of accuracy. The measuring elements or resistance bulbs are interchangeable. If one is accidentally destroyed, it can quickly and inexpensively be replaced by another. Standardization at proper intervals keeps accuracy permanently constant. Information on request.



Sensitive and accurate over the entire range from -40°F to 300°F, Bristol's Electric Indicating Thermometer consists of (1) as many resistance bulbs as there are locations where temperatures are to be taken, (2) a multiple point rotary switch for connecting into instrument circuit any one of the several bulbs, (3) the indicating instrument with extra wide temperature scale, (4) a modified form of Wheatstone bridge having four resistance arms (two of which are equal, a third which is equal to the resistance of the bulb at the highest scale temperature, and a fourth arm which is equal to the resistance of the bulb at the lowest scale temperature), together with (5) a battery, (6) standardizing rheostat, and (7) a double throw switch for substituting the bulb for the fourth bridge resistance arm.

THE BRISTOL COMPANY · WATERBURY, CONN.

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